COLLEGE BOTANY SERIES—2

A TEXT BOOK
OF
PRACTICAL BOTANY

VOLUME 2

D R Dubey
B Sc II

By

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TO MY WIFE

MRS. MANJULIKA LAXMIE,

SON AMITABH *AND DAUGHTER* ARPITA

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PREFACE

It is a matter of satisfaction to me that this volume of A Text-Book of Practical Botany' is being brought out by the publishers.' The earlier first volume, it is gratifying to note, was widely and warmly welcomed both by the teachers and the taught. The present volume is meant primarily for the use of students going up for the B. Sc. Final degree examination of the Universities of Allahabad and Gorakhpur but the material provided covers the courses of studies prescribed by the sister universities of the State of Uttar Pradesh.

I have made every effort to introduce the subject in a manner which is simple, direct, engaging and effective and at the same time rewarding at the examination.

A special feature of the book is the large number of diagrams and copious illustrations. It is to be hoped that my fellow workers in the teaching community will find them both adequate and helpful.

It is my very pleasant duty to express my deep sense of gratitude to my colleagues, friends and well wishers for the cooperation and guidance they have extended to me. I am also indebted to the workers in the field of botany whose writings I have drawn up in preparing this volume.

I am specially thankful to our Principal, Sri J. P. Srivastava, Ex-M.L.C., himself a professor of Botany, Dr. S. N. Dixit, Reader in the Department of Botany, University of Gorakhpur, Dr. M. N. Tewari of Jodhpur University, Dr. Rajendra Singh of Gorakhpur University and my colleagues of the department in the C. M. P. Degree College of the University of Allahabad, Sri R. C. Srivastava, Dr. D. N. Lal, Dr. A. S. Srivastava, D. Sc., Sri Rajeshwar Prasad, Sri Surendra Nath, Dr. R. P. Srivastava, Dr. V. K. Laloraya, Dr. H. N. Srivastava and Dr. V. Bhargava who have rendered willing assistance in various ways. I take this opportunity of expressing my gratefulness to the Regional Botanist and other members of the Botanical Survey of India Central Circle, Allahabad for gracefully allowing me the use of their well-stocked and uptodate Library. I am also thankful to the artists, Sri Mohammad Hussain of the Allahabad University and Sri Anis Rizvi for their neat work.

I should also like to recognise the assistance received from Sri Girdhari, the seniormost peon of the department, who has always been helpful in the collection of plants and the preparation of herbarium sheets ever since I joined the teaching staff of the college back in 1963.

I am full of gratitude to my friend Sri Rajendra Pal Narula for the keen and cordial interest he has taken at every stage in the preparation of the manuscript and the publication of the volume.

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GENERAL DIRECTIONS

HISTORY OF PLANT SCIENCE

Utilitarian reasons have given rise to most science and Botany is no exception. Early Indian works on Botany like 'Ayurveda', 'Charak-Samhita' and 'Sushruta-Samhita' were written keeping in view the utility of plants to man. Jivaka was asked by his 'guru' Bhikshu Atreya one of the most renouned teachers of University of Taxilla, to study the properties of all plants growing within a distance of four 'Yojanas' of the University campus. The medicinal properties of plants were studied by renowned medical men like Dhanwantari, Nagarjun, Agnivesa Jatukarna and Bhela Harita in ancient times. This clearly shows that importance of plants was realized from times immemorial, but laboratory studies in Botany are comparatively recent development.

Germany is the first country where laboratory studies in Botany were made possible in the universities, about a century age, with the advent of the Student's Microscope. The microscope is the biologists primary instrument. Probing the secrets of nature has always been the delight of the researcher. The pleasure to be derived by unfolding the secrets of nature is available to each and every student who can collect plants and study them in the laboratory. All he needs is a little patience and a little imagination. Books and teachers can only provide guidance and a sense of direction. The object in the pages of this book is to provide just the guidance and direction so as to make the study of the subject easy and rewarding.

LABORATORY WORKS

Practical work in Botany falls into two parts :

(a) the collection and study of piants in nature by the student himself as far as possible, (b) the study of plants inside the laboratory.

Real knowledge in Botany can be acquired if the plants are studied by the student in the laboratory and he himself applies his mind to the task of interpretation.

This book deals only with the practical work in the laboratory. Average specimens have been used for the descriptions and illustrations. Variations are always possible, and students are advised to make critical studies themselves in the laboratory. Work in the laboratory must be conducted under a code of discipline :

1. Always reach the laboratory in time. If you are late, you can not finish the work in time.

2. Work should not be done in a mechanical way. Take the help of your teacher, if you fail to understand anything.

3. The significance of each assignment should be recognised.

4. Read the instructions carefully before you begin an exercise.

5. Always do the work independently and honestly. Do not take any assistance from your fellow student. You yourself should interpret your work. Do not copy others.

An ancient story illustrates very well the ethical aspect of plant collection. Roaming in search of medicinal plants, Charak Muni, the court physician, came across an entirely new specimen of a flower in a farmer's field. His young disciple standing nearby saw that the master was interested in it and offered to pluck it for him. 'No', said the master, 'it is theft to take it without the farmer's permission.' The disciple argued that, as the physician, he had the king's permission to pick up any specimen from any where he liked. 'No,' again said the master, 'there is an ethical and moral aspect involved apart from the king's permission'. And the young disciple had to travel a distance of three miles to secure the permission of the farmer before the master would allow him to add the particular flower to the collection of thousands other specimens made earlier by the Muni.

Laboratory is a place where you have to develop moral values for your future life. So do not take out anything from the laboratory or from your fellow student without his knowledge and express permission. Success is bound to come if you work independently and honestly.

DRAWINGS

Always bear two things in mind :

(a) accuracy and (b) neatness.

1. Out lines should be continuous and distinct.
2. Every line must represent some structure.
3. Shading is unnecessary and should be avoided.
4. Drawings should be large enough to show necessary details. Use both low and high magnifications of the microscope.
5. Do not attempt rough sketches. Nothing should be left to finish outside the laboratory and all work should be completed in the laboratory within the scheduled time.

NOTES

1. Notes should be taken while studying the actual specimen. These should not be taken after the drawings have been made.
2. For taking down notes do not consult other members of the class. Never copy from a book. This will mar your power and ability to interpret things and arrive at independent conclusions.
3. Complete facts should be given in describing an experiment regarding the object, material used, procedure, observations and your conclusions.
4. Structures revealed under low and high powers of the microscope should be recorded.
5. Show your work to your teacher and make necessary corrections.

NECESSARY MATERIAES

In order to carry out the practical work efficiently every student is advised to keep the following materials (equipments or accessories) with him on the seat in the practical laboratory.

1. Practical note book.
2. Two pencils (one hard, one soft).
3. Rubber.
4. Razor blade with hollow ground of good quality.
5. Safety razor blade.

6. Scalpel (very sharp).
7. A pair of small scissors.
8. Eorceps (one pair).
9. Two needless mounted in wooden or plastic handle.
10. Brush (medium seized and preferably camel haired).
11. Three watch glasses.
12. Two petridishes.
13. Slides (3 X 1" Size).
14. Cover slides (cover-glasses) 3/4" circles or squares.
15. Dropping bottles for reagents and stains (six in number) in a wooden rack.
16. Pins.
17. A silk cloth or clean white handkerchief.
18. Dropper.
19. Foot scale.
20. A good pocket hand lens.
21. A Dissecting Microscope.
22. A Light Microscope.

Note—When you finish section cutting, the razor (blade) must be greased to prevent it from rusting.

MICROSCOPE

The word 'microscope' is made up of two Greek words meaning 'small' and 'see'. There are several kinds of microscopes. An Electron Microscope can magnify a tiny object upto 100,000 times.

DISSECTING MICROSCOPE

Dissecting Microscopes are very simple. There is a basal 'foot' connected to a short 'limb'. The 'stage' is made up of a glass plate. There is a 'screw' for focussing. Light is adjusted with the help of a 'miror' attached to the limb below the stage. A simple magnifying 'lens' is put in the 'folding arm.'

Before the material is dissected out it is put on a slide which is kept on the 'stage' and is fixed with the help of clips. This is focussed by the screw and the length is adjusted by the 'folding arm'. In the 'folding arm' a lens is fitted. The object to be dissected out gets magnified. Its working is very simple. This magnifies an object from 4 to 40 times.

COMPOUND MICROSCOPE

This is one of the most commonly used microscopes. It is a costly instrument. Every student must thoroughly understand the working of its various parts.

1. Base—provides firm support and bears the weight of the microscope.
2. Arm—supports body tube and course adjustment.
3. Stage—A slide is placed on the stage over hole. The hole admits light from the mirror below.

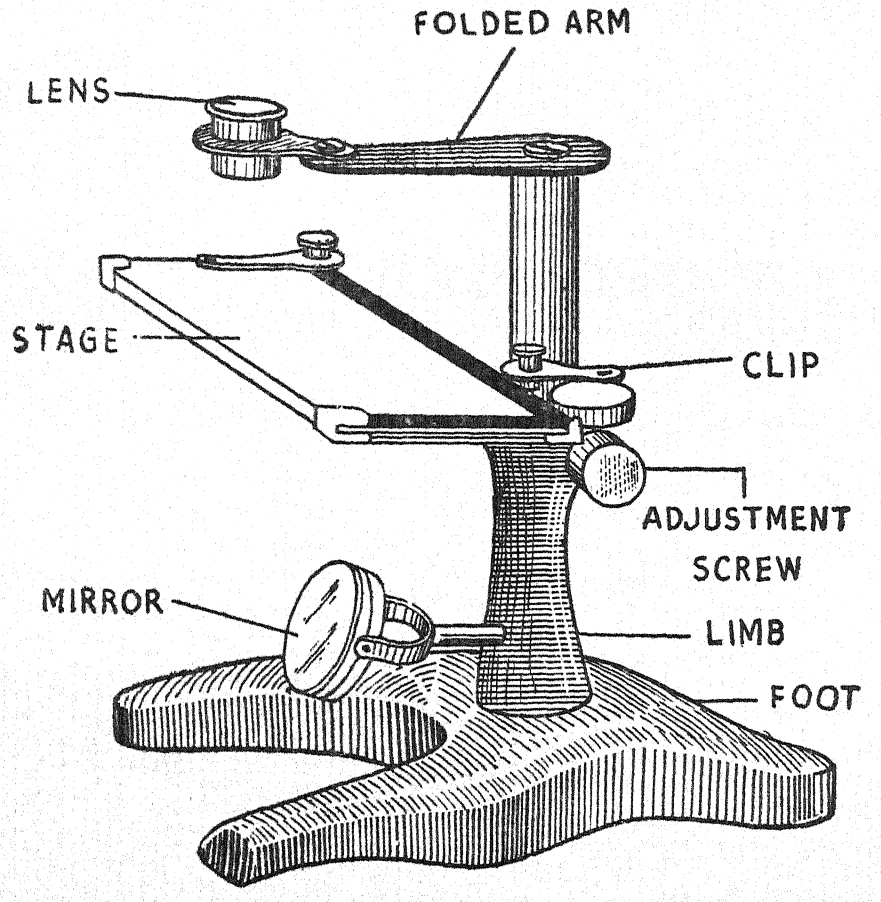


Fig. 1. Dissecting microscope

4. Diaphragm—regulates the amount of light passing through the specimen.

5. Clips—the slide is fixed on which an object for dissection is placed.

6. Mirror—it is attached to the arm below and reflects light upward through the diaphragm and the hole in the stage.

7. Ocular—ocular contains lenses. It can be replaced with another having higher or lower magnification.

8. Body tube—this holds the lenses of the ocular and the objectives at the proper working distance.

9. Coarse adjustment—the body tube can be moved up and down approximately to the correct distance from the object.

10. Nose piece—the low and high power objectives can be interchanged.

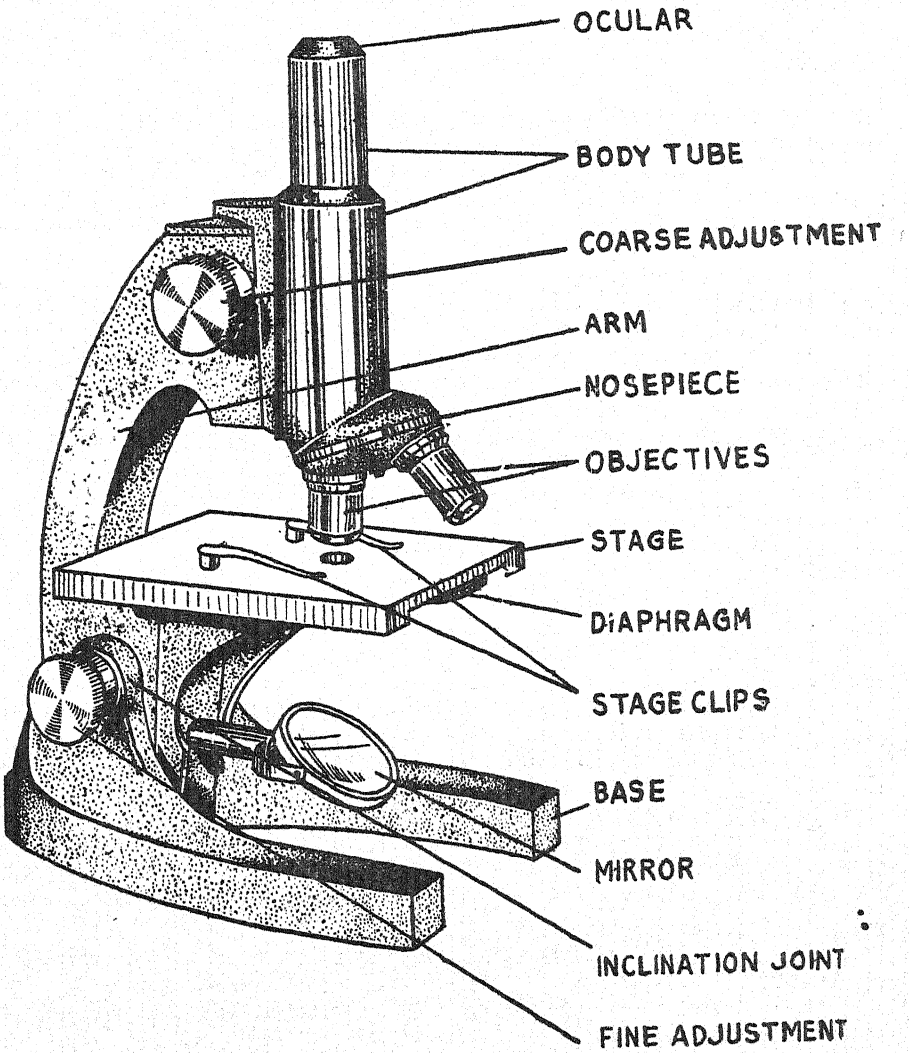


Fig. 2. A student-type compound microscope

11. Objectives—these contain lenses of the different magnifications. The lower power objective is 10X and the high power objective is 43 X.

12. Inclination joint—this is helpful in tilting to make adjustments to the eye level.

13. Fine adjustment—exact focussing can be done by moving the stage or body tube up or down very slightly.

A Compannd microscope can magnify an object 1000 to even 2000 times its normal size.

Uses of the microscope

1. The mirror and all the lenses should be clean before you use the microscope. A clean handkerchief or tissue paper may be used for this purpose
2. Light should come from the northern side and the microscope should be kept in a well lighted place while working with it.
3. Place the slide (with the mounted material), just above the aperture, on the stage.
4. Use the concave side of the mirror, look through the eye-piece, and adjust the light.
5. First focus in low power with the help of coarse adjustment. Never focus in high power directly. Do not try to focus under high power without a cover slip.
6. If you want to see a particular portion under high power of the microscope, first focus it under low power, keeping the particular portion in the centre and then turn the nose piece very slowly and carefully to high power objective. Fine screw adjustment should be used for focussing.
7. Keep both the eyes open while examining an object under the microscope. Unnecessary stain on the eyes will thus be released.

SECTION CUTTING

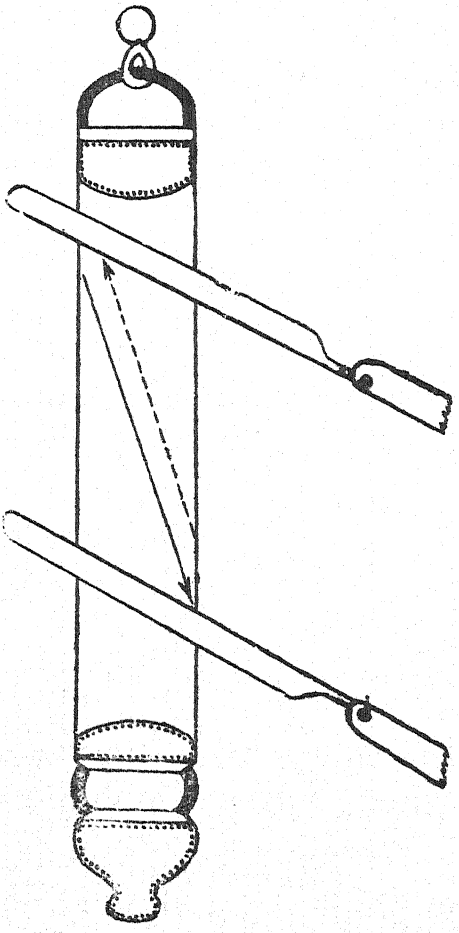
Always use a razor for cutting sections.

Procedure :

1. Hold the material between the thumb and the fore finger of the left hand.
2. If the material to be cut is very small or delicate it should be kept in a piece of pith.
3. The material to be cut should be kept moist during the whole process of section cutting.
4. The fore finger should be horizontal and the tip of the thumb should always be kept at a lower height.
5. Hold the razor with the right hand.
6. Keep a few drops of water on the surface of the blade of the razor.
7. The razor should be held in a position where blade and handle meet and form an angle of 90°.
8. Keep the handle free and put your index finger on the hooked end of the razor.
9. The back of the blade should be pressed and held tight by first' second and third fingers.
10. Press the milled surface of the thick shank of the blade with the thumb.
11. The pith should be thin and soft.
12. Split the pith longitudinally or make a groove in it according to the need. The pith is made from pieces of roots of carrot or radish or even potato.
13. Hold the pith in the left hand (the material embedded in it) and slide the blade of the razor over it.
14. In order to get a thin and uniform section, move the razor quickly and cut a section in one stroke.
15. After cutting sections, the blade should be dried immediately.

STROPPING AND HONING

1. The leather side of the belt is oiled during stropping and then the razor is moved over it.



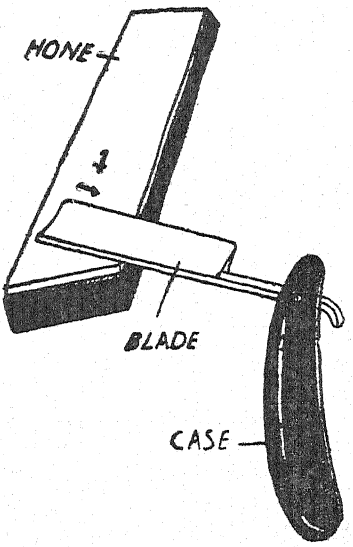


Fig. 3. Showing stropping. Fig. 4. Showing honing.

2. Then the other side (canvas side) of the belt is used.

3. Honing is necessary if the edge of blade of the razor becomes blunt. The razor should be moved obliquely (oblique strokes) on a hone (fine oil stone).

4. The stropping and honing should be done very carefully and the strokes should be slower.

The Planes

1. In case of roots and stems which are cyliddrical organs, a transverse section (T. S.) or cross section (X. S.) is cut by keeping the material in vertical position.

2. For longitudinal sections (L. S.) the plant organ should be kept horizontally.

When the material is cut along the radius, the section is called a radial longitudinal section (R. L. S.), and when the material is cut along the tangent, it is called tangential longitudinal section (T. L. S.).

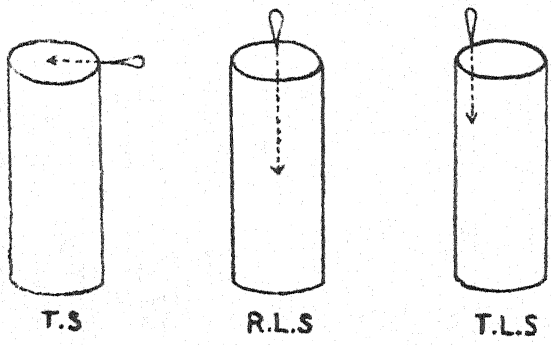


Fig. 5. Showing the different planes.

3. The sections of the dorsiventral organs e. g. leaf or thallus of a liverwort (*Riccia*), the section is vertical transverse section (V. T. S).

STAINING

Tissue differentiation is possible only by staining the different tissues with different colours. The stains are the chemical dyes. They react with the cell wall and different colours are imparted by different statins. The section (or the whole plant, alga or fungus) is stained either with only one dye or with two dyes. Staining with only one dye is known as single staining e. g. lower plants which do not show cellular differentiation or tissue differentiation. Staining with two dyes is known as double staining, one is acidic while the other is basic. Unlignified and thin walled tissues are stained with acidic dye and lignified, thick-walled tissues are stained with basic dye.

Some of the common stains ara given below ;

1. **Safranin**—2.5 gms. of safranin is mixed with 100 ml. of 95% alcohol. This mixture is slightly warmed. 25 ml. of this solution is mixed with 75 ml. of distilled water. For permanent slides, safranin is prepared in 50% alcohol and for temporary staining, safranin is made in water (1 gm. of safranin is dissolved in 100 ml. of water). Safranin stains lignified tissues e. g. sclerenchyma, prosenchyma and xylem.

2. **Haematoxylin**—This stains non-lignified thin walled tissues like parenchyma, collenchyma, endodermis, cambium, cork cambium, phloem and pith.

Compositian ;

Haematoxylin dye	0.5%
Alum solution	2%

Usually the haematoxylin is prepared in 90% alcohol. It is alsa prepared in water according to need.

3. **Methylene blue :**

Methylene blue	0. 3 gm.	)
Ethyl alcohol	30 ml.	) Salution A
Potassiym hydroside	0.01% by weight	
	100 ml.	Solution B

4. **Light green or Methyl green ;**

Light green	1 gm.
Alcohol (100 %)	25 ml.
Clove oil	95 ml.

5. **Gentian violet or Crystal violet ;**

Crystal violet	1 gm.	Solution A
Distillen water	1 litre	
Sodium bicarbonate	1 gm.	Solution B
Distilled water	20 ml.	
Solution A	1.5 ml.	mixed
Solution B	0. 4 ml.	

It stains lignified tissues.

6. **Aniline blue :** It is also known as cotton blue, water blue or china blue. Cellulose cell walls are stained.

Aniline blue	1 gm.
Alcohol (95%)	100 ml.

7. **Toluidine blue :**

Toluidine	0.25 gm.
Glacial acetic acid	2 ml.
Absolute alcohol	5 ml.
Distilled water	100 ml.

8. **Eosine ;**

Eosine	1 gm.
Water	100 ml.

This dye stains cytoplasm.

9. **Erythrosine bluish :**

Erythrosine	1 gm.
Absolute alcohol	5 gm.
Clove oil	95 ml.

It is used for staining gelatinous sheaths of algae.

10. **Cotton blue :**

Soluble blue	1 gm.
Lactophenol	100 ml.

It is used for staining of fungi.

11. **Lactophenol ;**

Phenol	100 gms.
Glycerine	100 ml.
Lactic acid	100 ml.
Water	100 ml.

12. **Basic fuschin ;**

It is used for nuclei and bacteria.

Basic fuschin	0.3 gm.	Solution A
Alcohol 95%)	10 ml.	
Phenol (metled)	5 gm.	Solution B
Distilled water	95 ml.	

13. **Acetocarmine :**

Glacial acetic acid	45 ml.
Distilled water	55 ml.
Carmine	excess

Before using this stain for staining nucleus, 2 drops of Ferric chloride solution (10%) is added in it.

14. **Picro-aniline blue :**

Aniline blue (1.5%)	22 ml.
Picric acid (5%)	78 ml.

15. **Bismark brown :**

Bismark brown	2 gm.
Alcohol (70%)	100 ml.

16. **Fast green :**

Fast green	1 gm.
Alcohol (70%)	100 ml.

This differentiates thin walled tissues.

17. **Iodine ;**

Iodine	1 gm.
Postassium iodide	100 ml.

Distilled water is added to dilute it.

It turns starch grains blue. It is used for differentiation of endodermis having starch grains.

COMBINATIONS OF STAINS FOR DOUBLE STAINING

1. **Haematoxylin and safranin**

Take two or three drops of safranin in a watch glass and transfer your section with the help of a brush from water to safranin. Keep it for 2 minutes. Take out the section with the help of a brush and again place it in another watch glass containing a few drops of 50% alcohol. Wash the section with 50% alcohol 3 or 4 times. Now the lignified cells become bright red See that no stain is there in the thin walled tissues. Now take one drop of haematoxylin in a clean watch glass, dip the section in it and after only 30 seconds take it out with the help of a brush and wash in water. See that the thin walled tissues become blue coloured. This section can be mounted in glycerine.

In a good stained section only walls are stained. The extra red stain can be removed by placing the section in a few drops of acid water in a watch glass. But care should be taken while using water. Give 3 or 4 washes in order to remove any trace of acid from the section.

Another method ;

A thin section is put in a watch glass containing a few drops of haematoxylin. The section is allowed to remain in it for 4 or 5 minutes. Excess

of stain is washed off with water. See that the lignified tissues are not stained. If the lignified tissues are also stained, remove the extra stain by destaining with acid alcohol. Wash repeatedly with water so as to remove completely the acid from the section. By dropping the section in ammonia water, the section turns blue.

Safranin (prepared in 50% alcohol) is taken in another watch glass. The section is put in it for a few minutes. The excess of stain is washed off with glycerine.

The following are some other combinations :

2. Safranin and Fast green. 3. Crystal violet and Erythrosine. 4. Safranin and Aniline blue. 5. Gentian violet and Bismark brown. 6. Gentian violet and Light green 7. Cotton blue and Lactophenol etc.

MOUNTING OF STAINED SECTIONS

A stained secton is mounted on a slide in the centre in mounting medium (glycerine or glycerine jelly for temporary slides, and canada balsam for permanent slides). The fungi are mounted in lactophenol. It is covered with a clean cover glass. There should not be even a single air bubble. The excess of liquid is removed.

Glycerine jelly :

And one part of gela in to 6 parts of water, boil and add 7 parts of glycerine. 10% phenol may also be added as preservative.

Procedure

1. The slide and the cover glass should both be as clean as possible.

2. Slides and cover glasses should always be held by thumb and point finger by their edges.

3. A cover glass should always be handled with care. It is fragile.

4. Do not touch the surfaces of the glass with your fingers. Always clean both the surfaces of the slide and the cover glass simultaneously with soft cloth.

5. Put a drop of glycerine on the slide in the centre with the help of a dropper.

6. With the help of a brush, transfer the stained section to the drop of the mounting liquid and push it by a needle so that it goes down at the bottom of the liquid.

7. Hold the cover glass in your left hand and touch the slide with one of its edges close to the drop of glycerine making an angle of approximately 45° to the slide and gently lower it with the help of a needle, in your right hand, until it covers the glycerine.

8. Bubbles (air) may be removed by gently tapping on the cover glass by the end of the handle of the needle or blunt end of a pencil.

9. If the liquid under the cover glass is not sufficient, then put a very small drop of the liquid near one of the edges of the cover glass on the slide. Now touch the opposite edge of the cover glass with a small piece of blotting paper.

10. The mounting liquid remaining out side the cover glass should be ubbed off with the help of a clean cloth.

RINGING

1. Seal the edges of the cover glass to the slide with coloured enamel.
2. This prevents evaporation of the mounting liquid.
3. Ringing is done with nail polish (with the help of nail polish brush).
4. It is done on a turn table.

LABELLING

1. Paste an one inch square paper on the left side of the slide written on it, the following ;

(i) Name of the material. (ii) Plane of the section. (iii) Date (iv) Place and (v) Name of the student.

2. Use gum in pasting the label.

FIXATIVES

1. **Formalin acetic-acid (F. A. A.) :**

Alcohol (50%)	100 ml.
Formalin	6.5 ml.
Acetic acid (glacial)	2.5 ml.

2. **Formalin alcohol :**

Alcohol (70%)	100 ml.
Formalin	6 ml.

3. **Chromic acid :**

Chromic acid	10 gms.
Acetic acid	13 ml.
Water	1 litre

Care should be taken not to use this solution for delicate materials.

4. **Flemming's weak solution :**

Chromic acid (1%)	25 ml.
Acetic acid (1%)	10 ml.
Water	60 ml.
Osmic acid (2%)	5 ml.

5. **Boutin's fluid :**

Picric acid (1.5% aqueous)	75 ml.
Formalin	25 ml.
Glacial acetic acid	5 ml.

6. **Navaschin-Karpechenko Lenglet (N. K. L.) fxative :**

Chromic acid 1 gm.		
Acetic acid 10 ml.		Solution A
Water 65 ml.		
Formalin	40 ml.	
Water	35 ml.	Solution B

Mix solutions A and B in equal amounts.

Most of the materials are kept in a mixture of 70% alcohol and 6% formalin.

HOW TO DESCRIBE A PLANT

Describe a plant under the following heads :

HABIT
ROOT
STEM
LEAF
INFLORESCENCE
FLOWER
CALYX |
COROLLA | PERIANTH
ANDROECIUM
GYNOECIUM
FRUIT
FLORAL FORMULA
CLASSIFICATION AND IDENTIFICATION

Habit—Herb/Shrub/Tree, climber/parasite/epiphyte/saprophyte etc.

Root—Tap/Adventitious, type/modification.

Stem—Herbaceous/woody, erect/prostrate, aerial/underground, modification i. e. rhizome/tuber/bulb/corm etc. runner stolon/offset/sucker, climbing, cylindrical/angular, fistular/solid, branched/unbranched, glabrous/hairy, type of hairs, colour of the stem, any other special feature.

Leaf—Cauline/Ramal/Radical, alternate/opposite/whorled, stipulate/exstipulate, simple/compound (number of leaflets, paripinnate/imparipinnate, sessile/sub-sessile/petiolate, shape, margin, apex, venation, glabrous/hairy, any other special feature.

Inflorescence—Racemose/cymose/solitary, spike/catkin/spadix/corymb/umbel/dichasial/monochasial/head or capitulum/cyathium/verticillaster/hypanthodium

Flower—Bracteate/Ebracteate, petiolate/sessile/sub-sessile, complete/incomplete, actinomorphic/zygomorphic, unisexual (staminate/pistillate)/bisexual, dimerous/trimerous/tetramerous/pentamerous, hypogynous/perigynous/epigynous/acyclic/spirocyclic/cyclic, colour etc.

Calyx—Number of sepals, polysepalous/gamosepalous, valvate/twisted/imbricate, shape, caducous/persistent.

Corolla—Number of petals, polypetalous/gamopetalous, valvate/twisted/imbricate, shape, colour, spur/nectary/corona present.

Perianth—Number of tepals (perianth leaves), polyphyllous (polytepalous)/gamotepalous, in one whorl/two whorls, sepaloid/petaloid, aestivation, colour.

Androecium—Number of stamens/polyandrous, monadelphous/diadelphous/polyadelphous, syngenesious/synandrous/obdiplostemonous, epipetalous/gynandrous, alternate with petals/opposite, filament long/short, didynamous/tetradynamous, introrse/extrorse, monothecous/dithecous, inserted/exerted, basified/dorsifixed/versatile, spur, any other special feature.

Gynoecium—Number of carpels number of locules, type of placentation marginal/parietal/axile/free central/basal/superficial, slyte terminal/lateral/gynobasic, number and shape of stigma, any other special feature.

Fruit—Simple/compound, legume (pod)/follicle/siliqua/silicula/capsule/Caryopsis/Achene/Cypsela/Nut Samara/Lomentum/Cremocarp/Regma/Carcerulus/Drupe/Berry/Pepo/Pome/Hesperidium/Elario of Follicles/Etario of Achenes/Etario of Drupes/Etario of Berries/Sorosis/Syconus.

FLORAL FORMULA

Floral formula is an easy or handy method of describing the characters of a flower with the help of shorthand notations or symbols. The various organs of a flower are represented as follows.

Br	—	Bracteate condition
Ebr	—	Ebracteate condition
Brl	—	Bracteolate condition
K	—	Calyx (whorl of sepals)
C	—	Corolla (whorl of petals)
P	—	Perianth (whorl of tepals)
A	—	Androecium (whorl of stamens)
G	—	Gynoecium (whorl of carpels)

The numbers constituting each whorl is written below the symbol.

♂	—	Unisexual staminate or male flower
♀	—	Unisexual pistillate or female flower
☿	—	Bisexual or hermaphrodite flower
⊕	—	Actinomorphic or regular condition
%	—	Zygomorphic or irregular condition
( )	—	Cohesion of floral parts in a whorl i. e. gamosepalous, gamopetalous, syncarpous condition.
( )	—	Partial cohesion of floral parts in a whorl
P A	—	Epiphyllous or epitepolous stamens (stamens fused with perianth)
C A	—	Epipetalous stamens (stames fused with petals)
G	—	Ovary inferior (epigynous condition)
G	—	Ovary half-inferior (perigynous condition)
G	—	Ovary superior (hypogynous condition)
K 2+2	—	Two whorls of calyx, each worls consisting of two sepals Cruciferae or Brassicaceae)
C 1+2+ (2)	—	Corolla Papilionaceous (Papilionaceae or Fabaceae)
P 3+3	—	Perianth members or tepals in 2 whorls of 3 tepals each.
A 5+5	—	Androecium with 10 stamens, 2 whorls, each whorl of 5 stamens (Caryophyllaceae)
A 2+4	—	Tetradynamous condition (Cruciferae or Brassicaceae)
A 2+2	—	Didynamous condition (Labiatae or Lamiaceae)
A (∝)	—	Stamens indefinite ; monadelphous condition (Malvaceae)
A (9) + 1	—	Diadelphous condition (Fabaceae)
STD	—	Staminode
Pistd.	—	Pistillode
∝	—	Indefinite or numerous number in a whorl
G 2	—	Bicarpellary, apocarpous condition
G (2)	—	Bicarpellary, syncarpous condition

FLORAL DIAGRAM

Floral diagram is the representation of the ground plan of a flower showing the arrangement of the various parts of the flower. It is best seen in bud condition as in the bnd all the floral members are present in their natural condition—Thus the floral diagram is an expression of characteristics of the floral parts and symmetry of the flower. The floral whorls, i. e. sepals, petals, stamens & carpels are represented on concentric circles. While making a floral diagram firstly find out the position of the mothe axis. The part of the flower towards the mother axis, is the posterior side and opposite to it is the anterior side. The mother axis usually occupies the posterior position. It is represented by a dot or a circle. It is not shown when the flower is terminal. In the diagram the sepals and petals are represented by hollow crescent outlines, stamens by transverse section of anthers, staminodes by dots and carpels are represented by the transverse section of the ovaries. All the floral members are drawn in relation to the mother axis. If a bract is present it is drwn below the floral diagram (anterior side) and the bracteoles (2 in number) at the sides. Count the number of sepals. If the number of sepal is odd then odd sepal is either posterior or anterior. Petals are also drawn likewise but see them carefully whether they are alternate (usually) or opposite the sepals. Likewise stamens are drawn but see carefully whether they are polyandrous or monadephous, diadelphous, polyadephous, tetradynamous, obdiplostemonous, syngenesious or epipetalous etc. If they are obdiplostemonous then the stamens of the outer whorl are drawn opposite to the petals. Extrorse anthers face petals and introrse face the gynoecium. Mark the arrangement of the stamens. See whether they are spiral, cyclic or whorled. Count their number in each whorl separately. Also mark the presence of spur, interstaminal glands etc.

Apart from the floral diagram, the following diagrams are necessary :

1. A portion of the plant showing the details of all the parts.
2. Longitudinal section of the flower.
3. A stamen.
4. The gynoecium.
5. T. S. of the ovary.

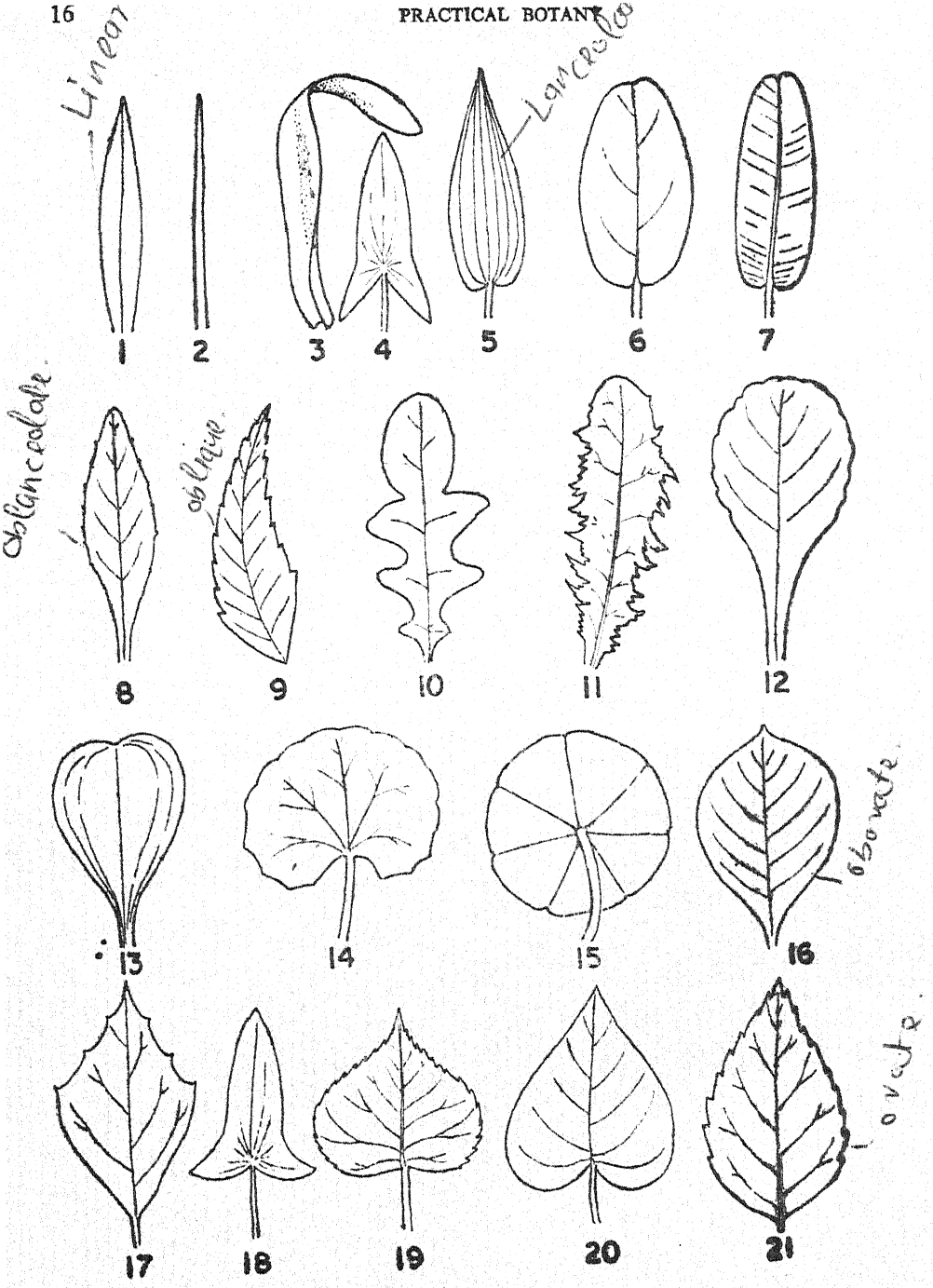


Fig. 6. (1—21). Leaf Shapes. 1. Linear 2. Acicular 3. Lorate 4. Sagittage 5. Lanceolate 6. Elliptical 7. Oblong 8. Oblanceolate 9. Oblique 10. Lyrate 11. Runcinate 12. Spathulate 13. Cuneate 14. Reniform 15. Rotund 16. Obovate 17. Rhombate 18. Hastate 19. Deltoid 20. Cordate 21. Ovate.

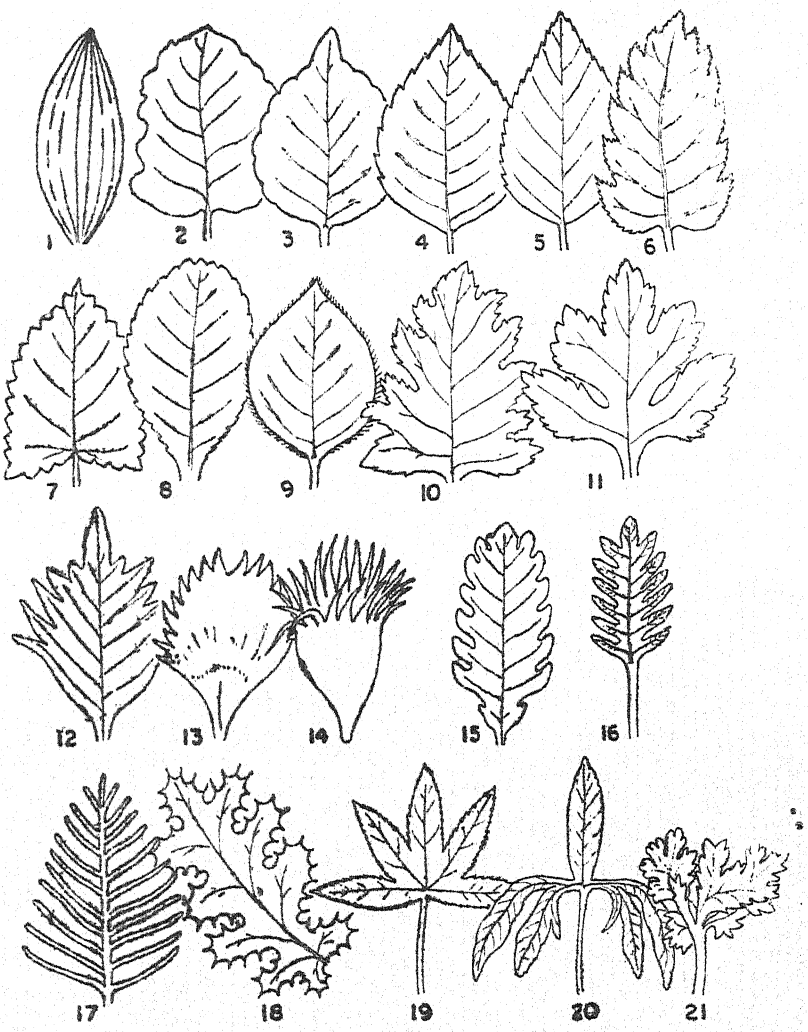


Fig. 7. (1—21). Leaf margins. 1. Entire 2. Undulate 3. Crenate 4. Serrate 5. Serrulate 6. Biserrate 11. Parted 12. Cleft 13. Incised 14. Laciniate 15. Lobed 16. Pinnatifid 17. Pectinate 18. Spinous 19. Palmate 20. Pedate 21. Crispate.

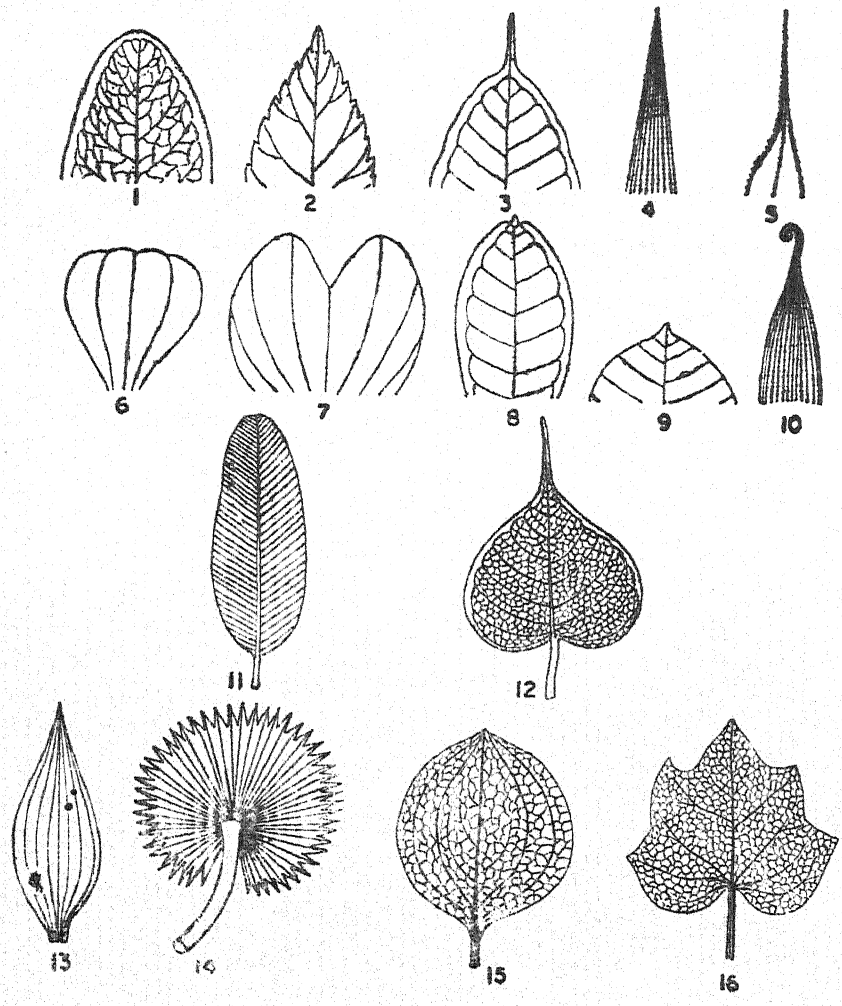


Fig. 8. (1—10). Leaf apices. 1. Obtuse 2. Acute 3. Acuminate 4. Cuspidate 5. Aristate 6. Retuse 7. Emarginate 8. Mucronate 9. Apiculate 10. Cirrhose.

& (11—16). Types of veination. 11. Parallel 12. Reticulate 13. Parallel convergent 14. Parallel divergent 15. Reticulate convergent 16. Reticulate divergent.

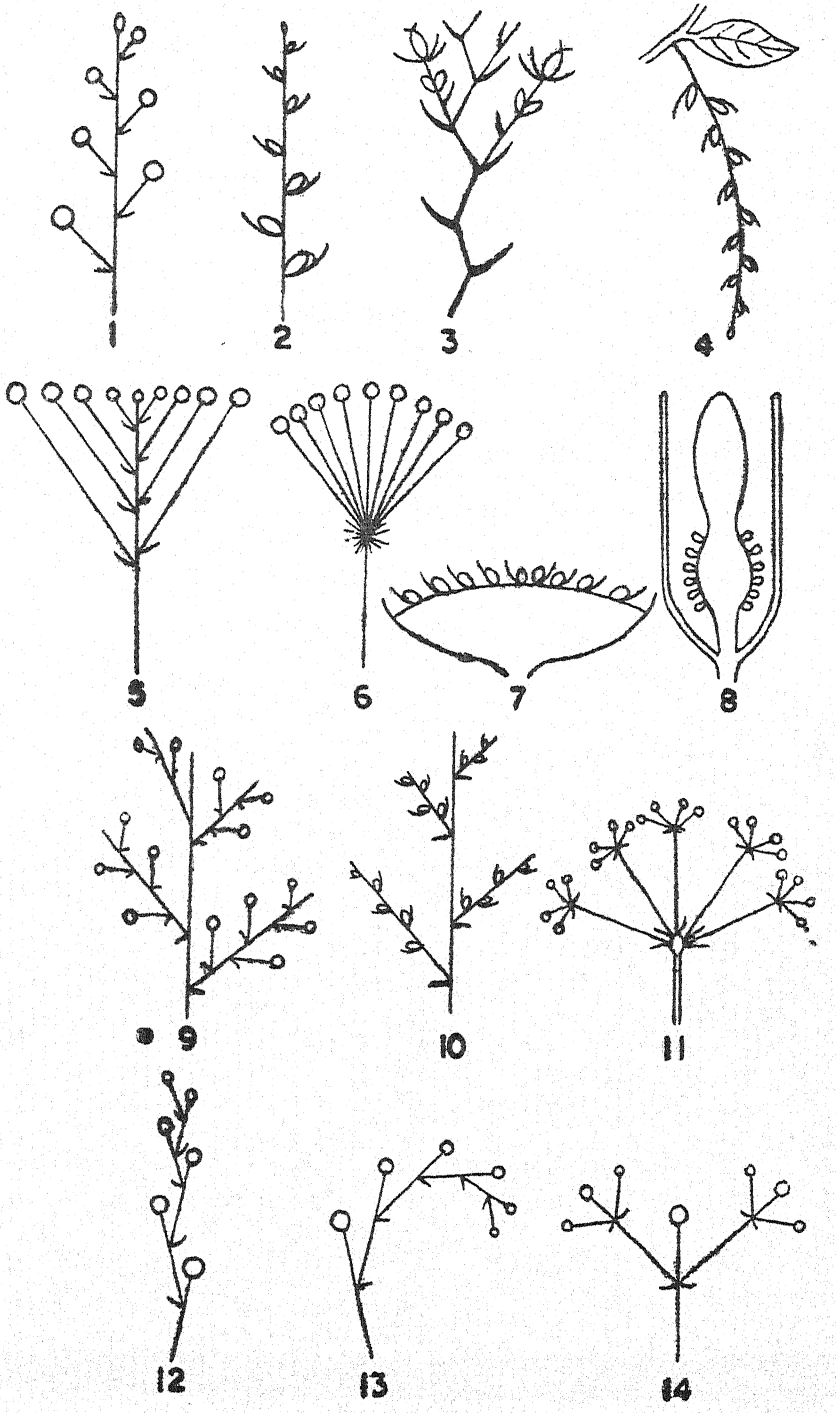


Fig. 9. (1—14). Kinds of inflorescences. 1. Raceme 2. Spike 3. Spikelet 4. Catkin 5. Corymb 6. Umbel 7. Capitulum 8. Spadix 9. Panicle or compound raceme 10. Compound

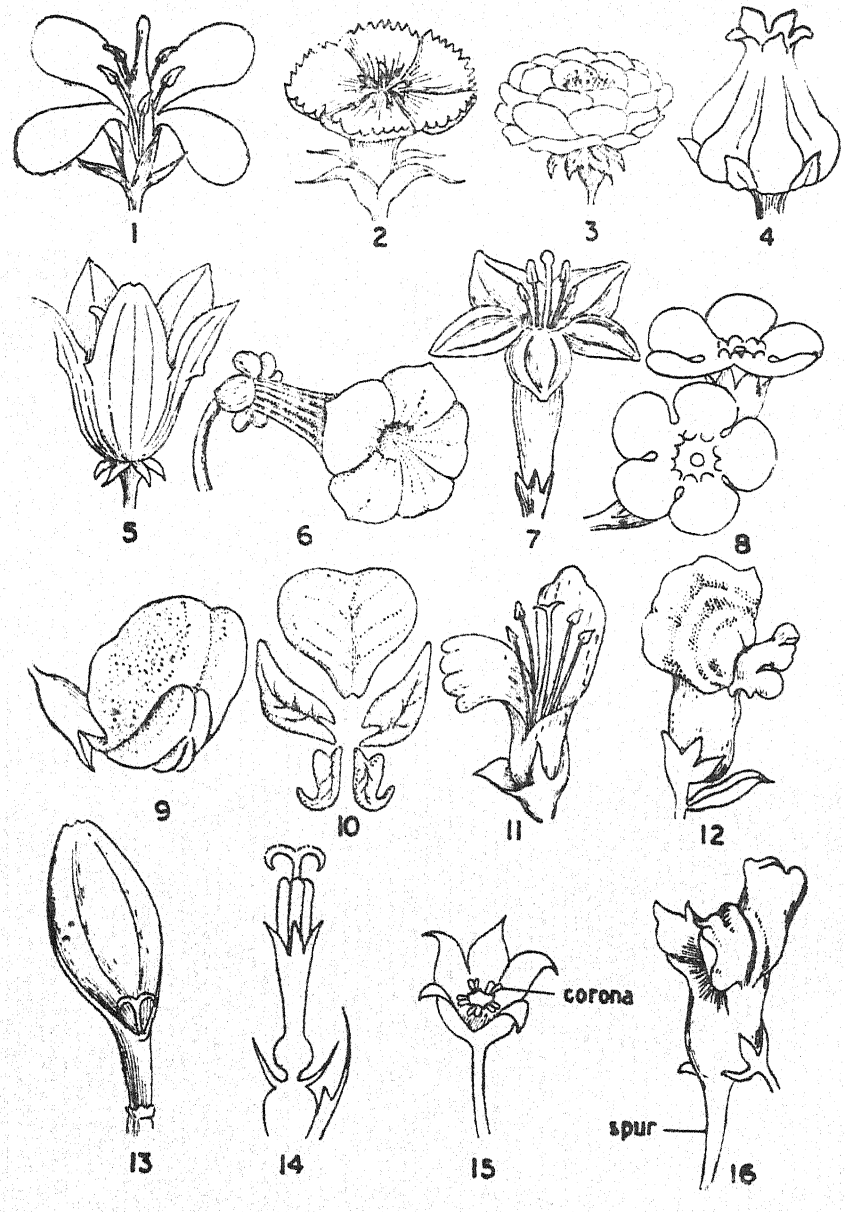


Fig. 10. (1—16). Shapes of corollas. 1. Cruciform 2. Caryophyllaceous 3. Rosaceous 4. Urceolate 5. Campanulate 6. Infundibuliform 7. Hypocrateriform 8. Rotate 9. Papilionaceous 10. Papilionaceous 11. Bilabiate 12. Personate 13. Ligulate 14. Tubular 15. Corolla with corona 16. Spurred corolla.

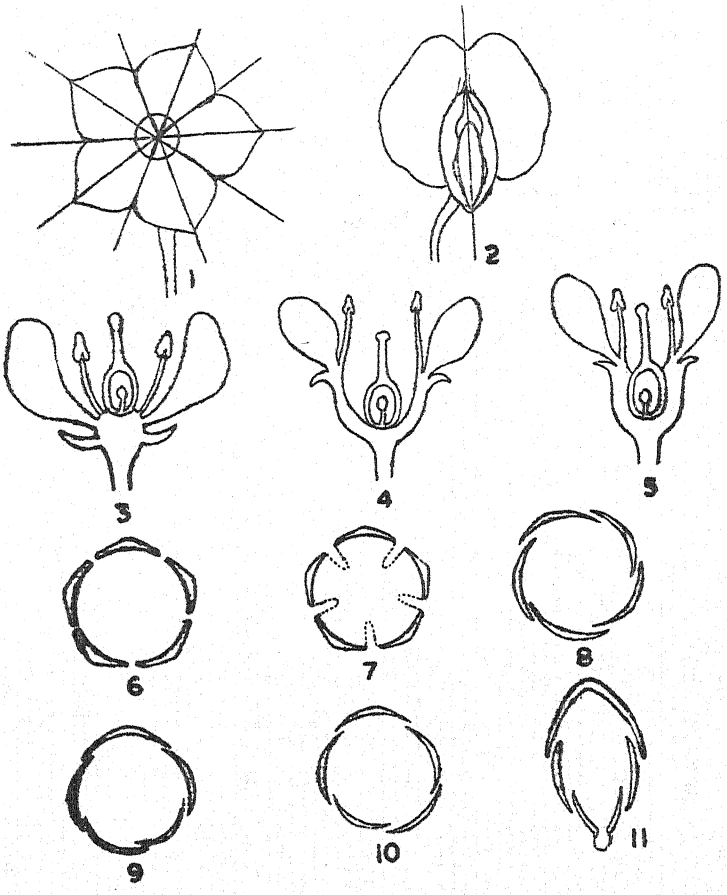


Fig. 11. (1—2). Symmetry of the flower. 1. Actinomorphic 2. Zygomorphic. 3, 4 & 5. Position of the floral members (sepals, petals, stamens & carpels) on the thalamus. 3. Hypogynous 4. Perigynous 5. Epigynous. 6—11. Aestivation types. 6. Valvate 7. Induplicate valvate 8. Twisted 9. Imbricate 10. Quincuncial 11. Vexillary.

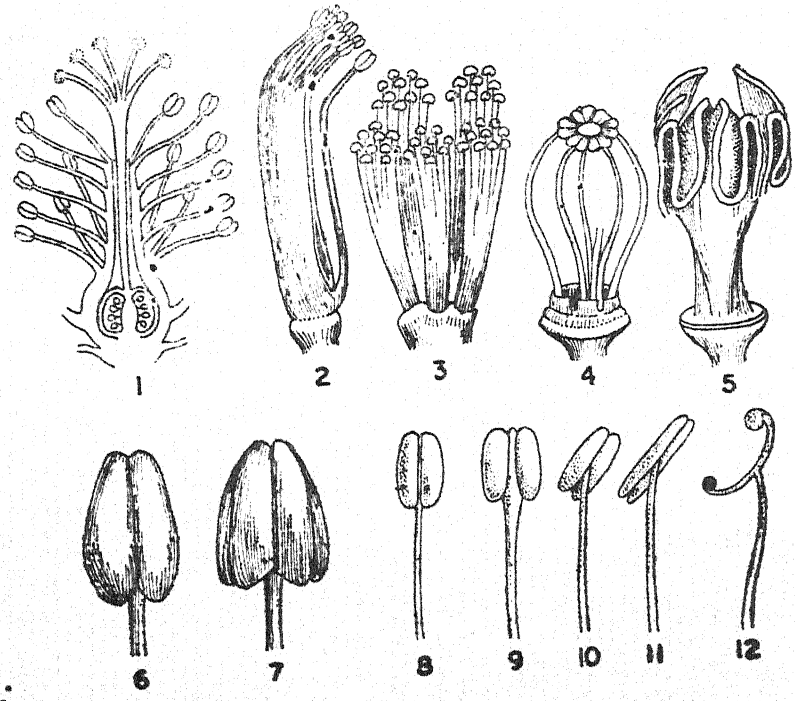


Fig. 12. (1—5). Cohesion of stamens. 1. Monadelphous 2. Diadelphous 3. Polyadelphous 4. Syngenesious 5. Synandrous 6 & 7. Monothecous and dithecous stamens 6. Monothecous 7. Dithecous 8—12. Fixation of the filament to the anther. 8. Basifixed 9. Adnate 10. Dorsifixed 11 & 12. Versatile.

CHAPTER 1

Morphology

ROOT

1. PLANT WITH ROOT-NODULES

(1) The root is branched tap root.

(2) The roots are of some leguminous plant and show root-nodules due to the presence of some bacteria e. g. *Bacillus radicicola* or *Pseudomonas radicicola*.

(3) The bacteria are present in the soil and enter the roots through the root hairs.

(4) These bacteria cause the development of the nodules or tubercles as a pathological growth.

(5) The bacteria supply nitrogenous substances to the roots and in return they receive other forms of nutrients. This is called *symbiosis*.

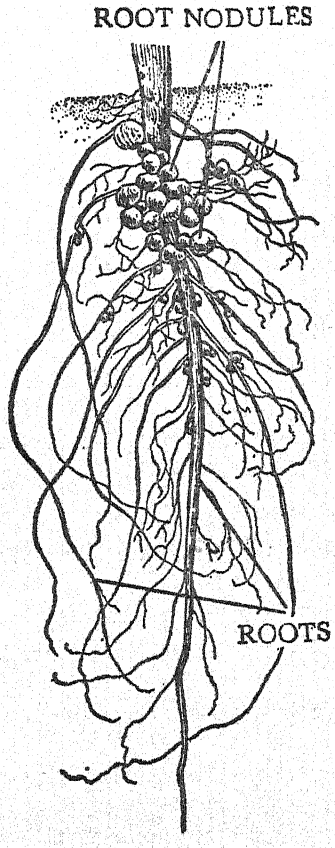


Fig. 1. Root system of some leguminous plans thowing root-nodules.

2. TUBEROUS ROOT

(1) This is a tuberous or tubercular root of the sweet potato (*Ipomoea batatus*) and belongs to the family Convolvulaceae.

(2) The root is swollen due to the accumulation of food material. It is edible. The shape is not definite.

(3) The tuberous root is produced singly and not in clusters.

(4) Adventitious buds are also seen arising from the root.

(5) Adventitious buds arise from a position other than the normal apex or axil.

(6) These buds are used for the propogation of the agricultural crop of the sweet potato.

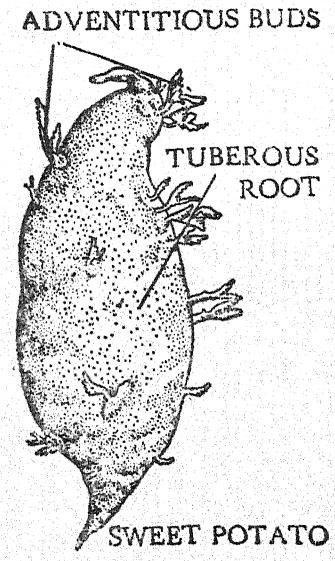


Fig. 2. Showing tuberous root of the sweet potato with adventitious buds.

3. FLOATING ROOT OF JUSSIAEA

(1) This is an aquatic plant (water plant or hydrophyte) of *Jussiaea repens* (Onagraceae).

(2) Adventitious roots grow from the nodes.

(3) Special roots also grow from the nodes in addition to the ordinary adventitious roots.

(4) These special roots are like masses of white cotton and are spongy in nature.

(5) These special roots help the plant to float and thus they are called *floating roots*.

(6) The floating roots contain a large amount of air and thus they also help in breathing or aeration of the submerged organs. When out of water, they dry and shrivel up very soon.

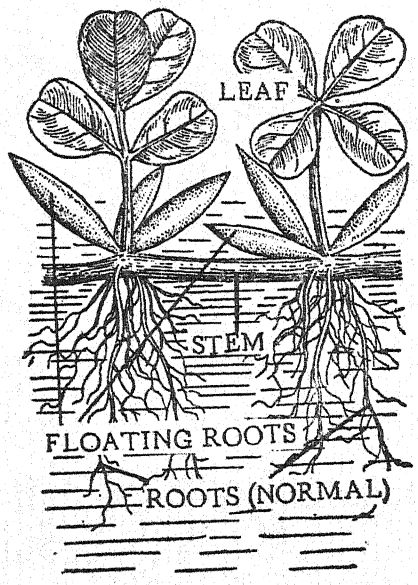


Fig. 3. Showing floating roots of *Jussiaea.*

4. CLINGING ROOT & AERIAL ROOT

(1) This is an epiphytic orchid plant (Orchidaceae).

(2) It has two kinds of roots.

(3) Aerial roots hang from the plant. These roots are greenish and are covered with a spongy tissue known as *velamen.*

(4) The velamen helps in the absorption of moisture from the atmosphere.

(5) Due to the presence of Chlorophyll they are also photosynthetic in nature.

(6) The clinging roots are thinner and help the plant to cling to its support.

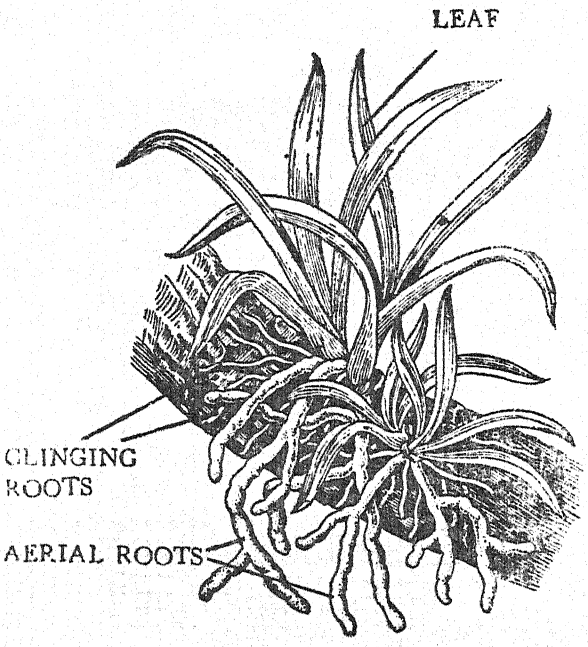


Fig. 4. An orchid plant showing *aerial* and *clinging* roots.

5. CLIMBING ROOT OF BETEL

(1) This is a plant of *Piper betle* (Piperaceae) showing climbing roots.

(2) The stems of the plant twine round the support and at certain points clasp the support. It appears as if the plant were tied to the support at these points.

(3) These points are nodes from where adventitious roots are given off.

(4) These adventitious roots help the plant to climb on its support and thus these roots are known as *Climbing roots.*

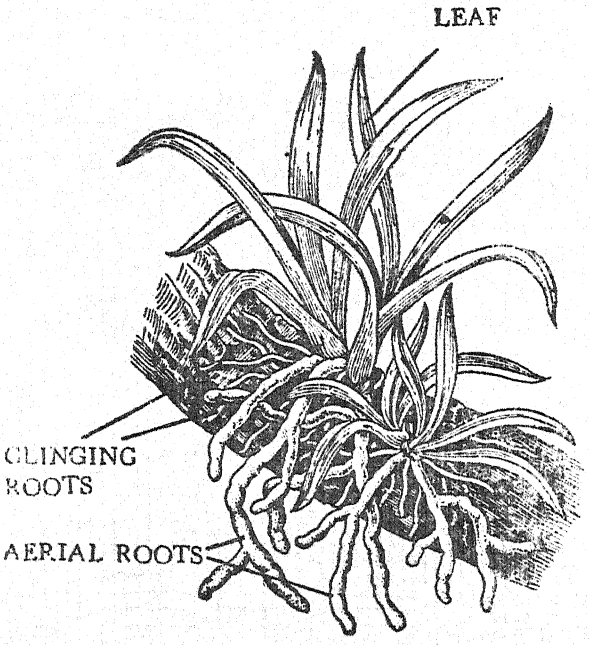


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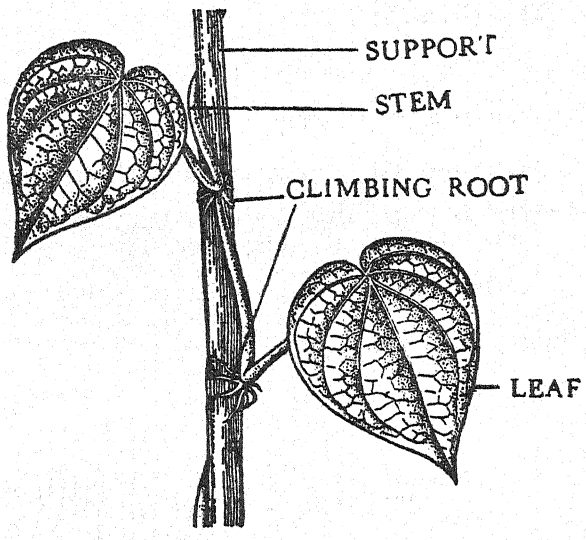


Fig. 5. A climber plant *of Piper betle* showing climbing roots.

STEM

1. STOLON OF MENTHA

(1) This is a *Mentha* plant showing *Stolon.*

(2) Stolon is a special type of runner (stem).

(3) In this the stems do not grow horizontally but at first grow upwards and then arch or bend down.

(4) On touching the ground or soil, the stems form daughter plants.

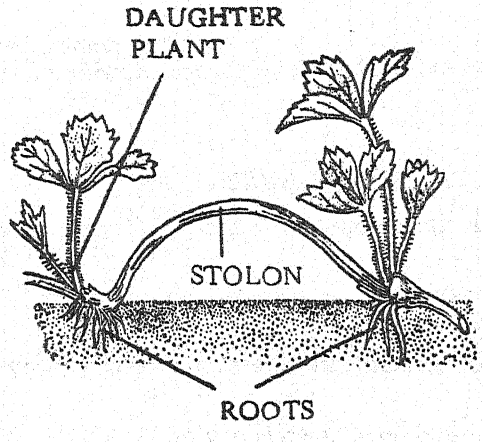


Fig. 6. Showing natural stolon of *Mentha sp.* (Labiatae or Lamiaceae)

7. OFFSET OF EICHHORNIA

(1) This is a plant of water hyacinth (*Eichhornia crassipes*).

(2) The plant is a free-floating hydrophyte.

(3) The stem is justlike a runner but it is shorter and thicker.

(4) Adventitious roots are given off from the nodes. Root tips have root pockets. These roots provide buoyancy to the plant.

(5) Leaves arise from the nodes and have spongy and swollen petioles which help the plant to float. The bulbous spongy floats (petioles) develop air cavities.

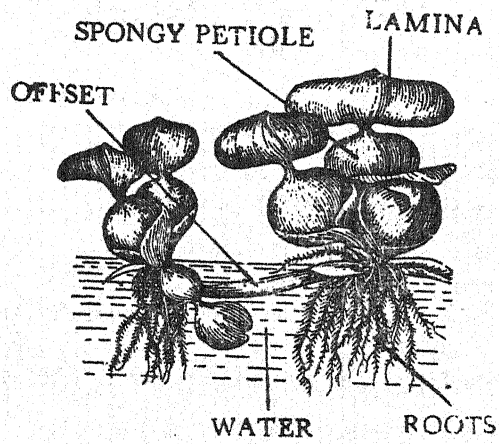


Fig. 7. A free-floating plant of water hyacinth of Pontederiaceae showing offset stem.

8. ORCHID WITH PSEUDOBULBS

(1) This is an epiphytic orchid plant growing on a branch of a tree (support).

(2) The internodes of the stem become fleshy and tuberous structures.

(3) These structures store moisture to tide over unfavourable dry conditions.

(4) These are known as *pseudobulbs*.

(5) Aerial roots are photosynthetic in nature.

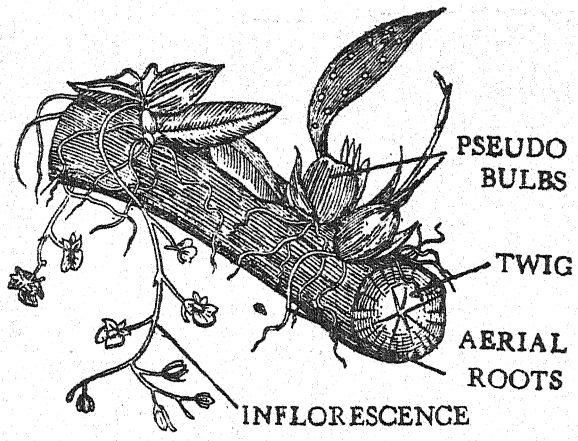


Fig. 8. An orchid plant with pseudobulbs.

9. STEM-TUBER OF POTATO

(1) These are the tubers of potato (*Solanum tuberosum*) belonging to the family Solanaceae.

(2) In potato the tubers are modified underground stems.

(3) Adventitious branches grow from the underground part of the stem.

(4) The tips of these branches accumulate food material (starch), swell up and form tubers.

(5) Nodes and internodes are present but they are not well marked due to excessive swelling.

(6) On the nodes, scale leaves (in early stage) and *'eyes'* or rudimentary buds are present. The eyes are arranged spirally on the tuber.

(7) The tubers are covered by corky skin which is protective in nature.

(8) Adventitious roots are present on young tubers but absent on old tubers.

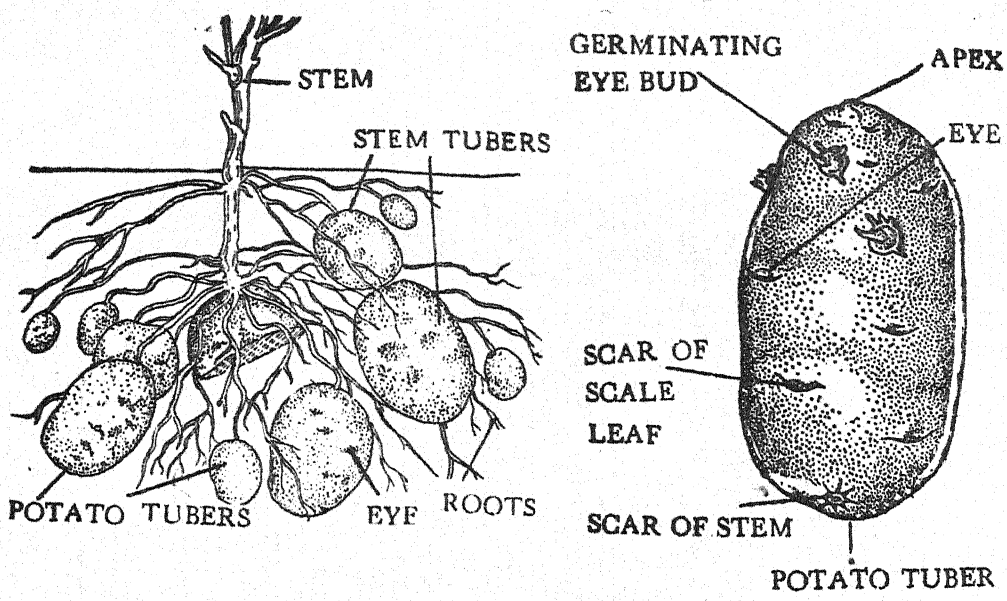


Fig. 9. Potato tubers showing Eyes and germinating buds.

(9) A scar is noticed on the tuber when it is detached from the stem. The scar is the point of attachment and is opposite the apex.

(10) The potato tubers are edible and are rightly known as the king of vegetables.

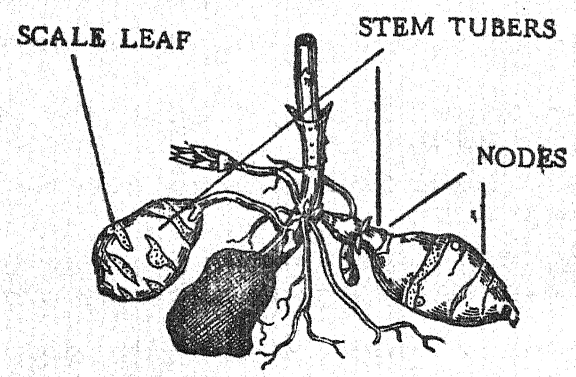
10. STEM-TUBERS OF HELIANTHUS

(1) These are the stem-tubers of vegetable artichokes or Jerusalem artichoke (*Helianthus tuberosus*) of Asteraceae family.

(2) The underground stems store inulin, become swollen and form tubers.

(3) Nodes and internodes are well marked on the tubers.

(4) Scale leaves are also present on the tubers.



STEM TUBERS OF HELIANTHUS

Fig. 10. Showing stem-tubers or *Helianthus tuberosus.*

11. RHIZOME OF GINGER

(1) This is the rhizome of ginger (*Zingiber officinale*) of the family Zingiberaceae.

(2) The *Rhizome* is an underground stem which grows horizontally and is dorsiventral.

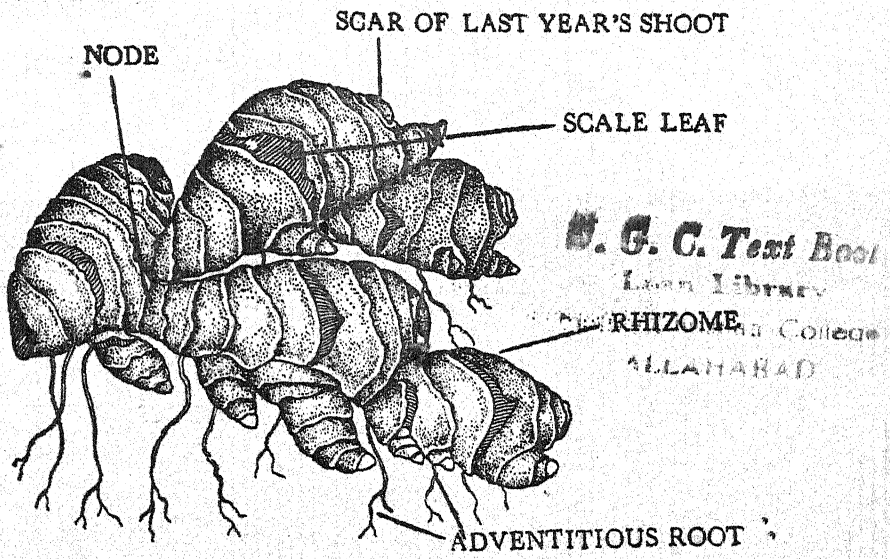
(3) The stem becomes fleshy and swollen due to accumulation of food material.

(4) Nodes and internodes are well marked.

(5) Scale leaves are present at the nodes.

(6) Axillary buds and apical buds can be seen.

(7) Adventitious roots arise from the lower surfaces of the nodes.



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Fig. 11. Rhizome of ginger showing apical buds, scale leaves, nodes and adventitious roots.

12. BULB OF ONION

(1) This is a bulb of onion (*Allium cepa*) of the family Liliaceae.

(2) The bulb is actually an underground modified bud.

(3) The stem is very short and disc-shaped and fleshy scale leaves grow from *it*. Adventitious roots arise from tbe lower surface of the stem.

(4) The internodes are compressed and the fleshy scale leaves arise from the nodes.

(5) At the apex there is an axillary bud which is seen in the bulb when all the fleshy leaves are removed or the bulb is cut longitudinally. The bud d evelops into a flowering scape.

(6) The food material is stored in the fleshy scale leaves.

(7) The bulb of onion is a *tunicated bulb* because the whole bulb is covered by some dry scale leaves which are thin and membranous. These form the *tunic* and are arranged in a concentric manner.

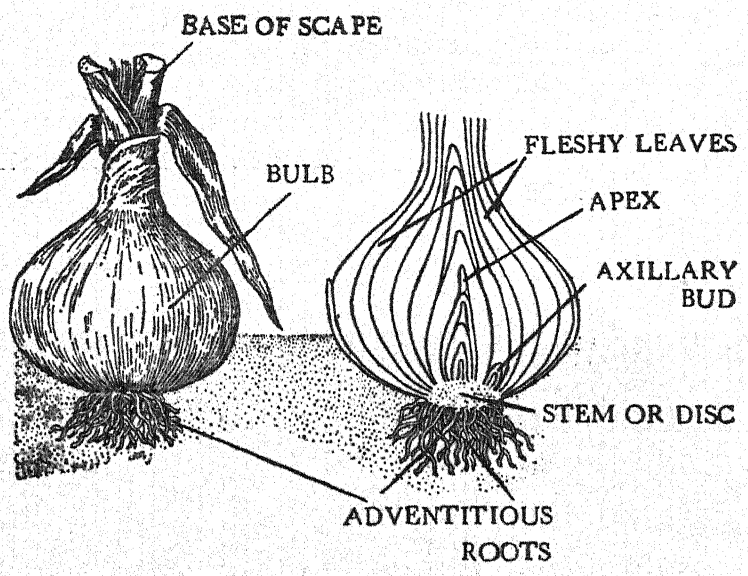


Fig. 12. Tunicated bulbs of onion showing fleshy leaves, bud, stem and adventitious roots.

13. CORM OF ZIMINKAND

(1) It is a corm of *Amorphophallus campanulatum* or elephant's foot (Araceae).

(2) It is a huge, condensed single internode storing a huge amount of food material.

(3) A number of adventitious buds are noticeable on it.

(4) There are some scale leaves and adventitious roots grow all over its body.

(5) Daughter corms are also seen with adventitious buds and adventitious roots.

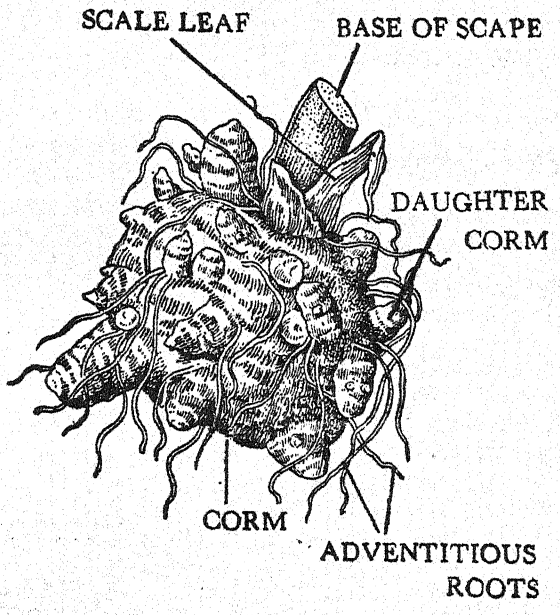


Fig. 13. Corn of *Amorphophallus.*

14. RUNNER OF HYDROCOTYLE

(1) This is a creeping herbaceous plant (*Hydrocotyle asiatica*).

(2) The plants are erect but give rise to small horizontal branches in all directions. These are called *runners.*

(3) These branches, after growing for some length, strike roots and give rise to new daughter plants.

(4) The daughter plants in their turn form grand-daughter plants in the same manner.

(5) Thus the *runners* serve as a means of propagation.

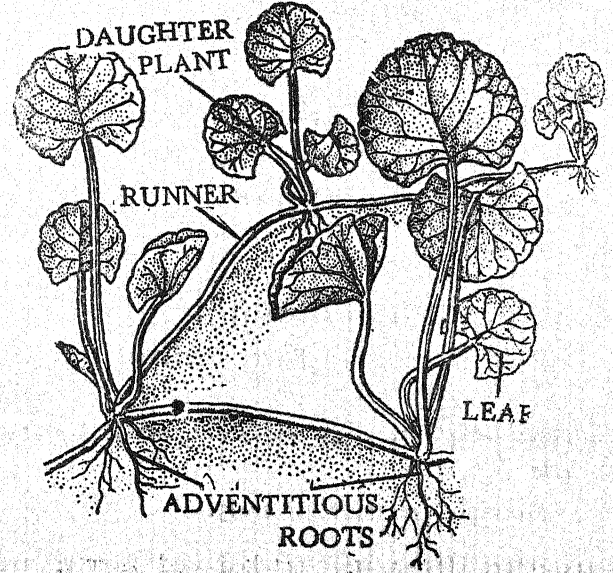


Fig. 14. *Hydrocotyle asiatica* (bramhibuti) of Umbelliferae with daughter plants.

15. PHYLLOCLADE OF OPUNTIA

(1) This is *phylloclade* or *cladophyll* of *Opuntia* (Cactaceae).

(2) It is a xerophyte plant.

(3) The internodes of the stem become flattened and green and are photosynthetic in function. These are called phylloclades.

(4) The leaves are modified into spines or scales so as to check the loss of water (transpiration).

(5) Flowers are present on the nodes.

(6) Phylloclade develops thick cuticle and contains mucilage. This helps to retain water.

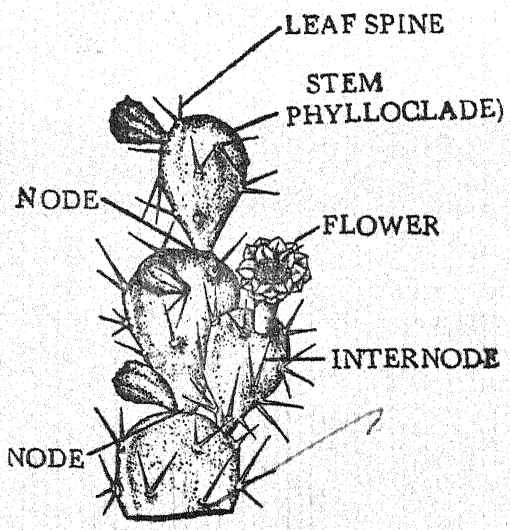


Fig. 15. Showing phylloclade of *Opuntia*.

16. PHYLLOCLADE OF MUEHLENBECKIA

(1) This is a twig of a xerophytic plant, *Muehlenbeckia* or *Coccoloba* (Polygonaceae).

(2) The internodes of the stem are flattened, green and photosynthetic and called *phylloclade*.

(3) The leaves are highly reduced or scaly.

(4) Nodes and internodes are well marked and flowers are present in the axils of leaves at the nodes.

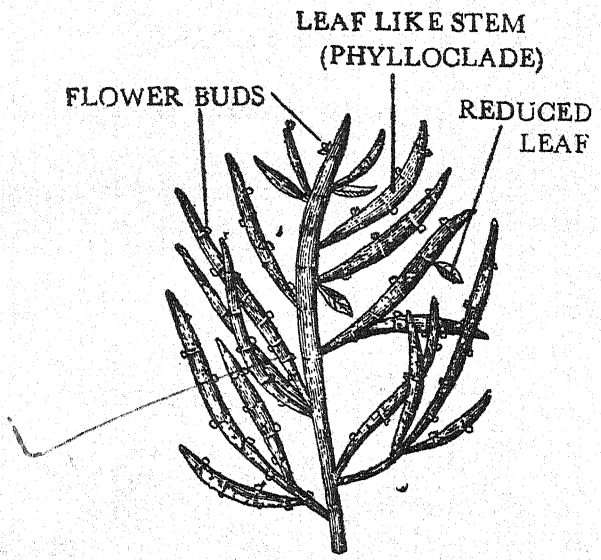


Fig. 16. A twig of *Muehlenbeckia* showing *phylloclade.*

17. PHYLLOCLADE OF RUSCUS

(1) This is a twig of xerophytic plant, *Ruscus* (Liliaceae).

(2) The internodes become flat, green, photosynthetic and leaf-like in appearance and are known as phylloclades.

(3) The phylloclade looks exactly like leaves with veins but the flowers indicate the positions of the nodes.

(4) The leaves are highly reduced and are scaly.

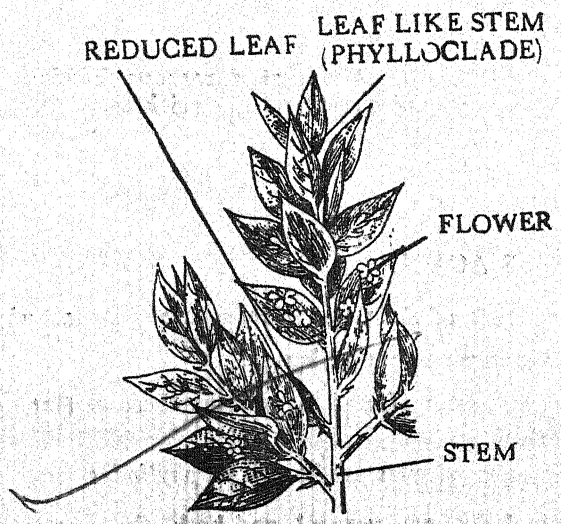


Fig. 17. A twig of *Ruscus* showing leaf-like phylloclades.

18. CLADODE OF ASPARAGUS

(1) This is a twig of *Asparagus* of Liliaceae.

(2) The branchlets consist of one internode only. These are not fleshy but cyindrical, green, photosynthetic and are mistaken for leaves and are called *cladodes.*

(3) The leaves are reduced and modified into prickles.

(4) The plant is able to check the loss of water and is a xerophyte.

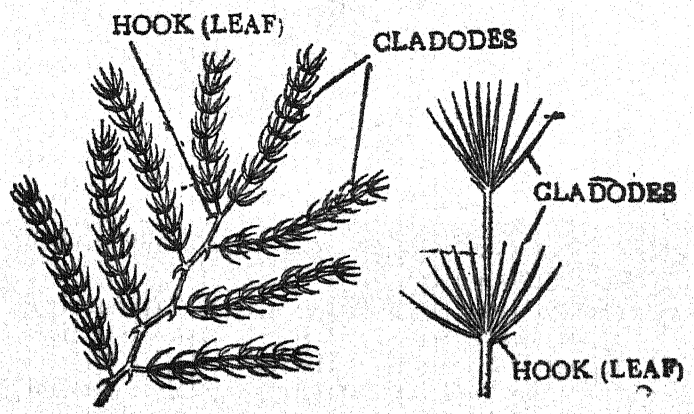


Fig. 18. A twig of *Asparagus* showing cladodes and hooks or prickles.

LEAF

1. PHYLLODE OF ACACIA

(1) This is a twig of *Acacia* of Mimosaceae showing *phyllodes.*

(2) The leaves are compound leaves.

(3) The leaflets drop off and the petiolets become flat, green, leaf like and photosynthetic.

(4) The modified petioles are known as *phyllodes.*

(5) The phyllodes are vertical and both the surfaces are exposed to light.

(6) The plant is a xerophyte.

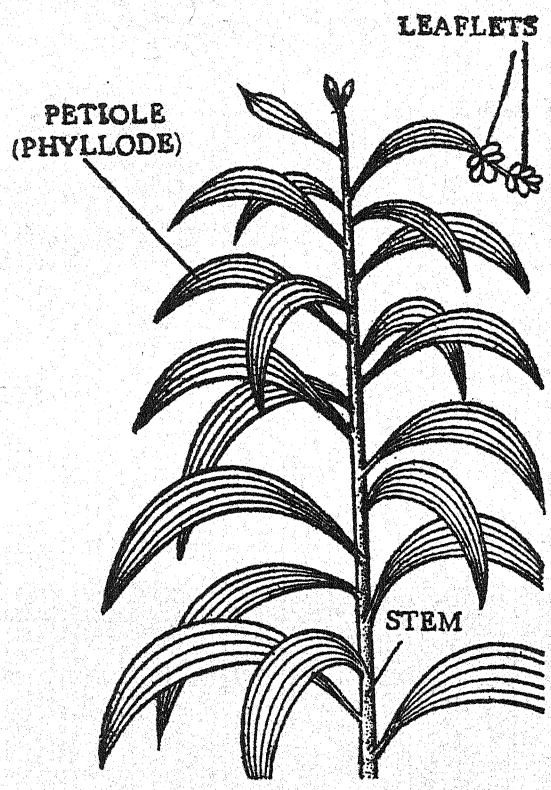


Fig. 19. A twig of *Acacia* bearing phyllodes.

2. PHYLLODE OF PARKINSONIA

(1) This is a twig of *Parkinsonia* of Cassiaceae (Caesalpiniaceae).

(2) *Parkinsonia* is a xerophyte.

(3) The leaf is a bipinnately compound leaf.

(4) The stipules are modified into spines.

(5) The primary rachis is short and is modified into a spine.

(6) The secondary rachis are also modified, not into a spine but into phyllodes, which become flat, green, photosynthetic and leaf-like in appearance.

(7) The pinnules or leaf lets are caducous and fall off soon to check transpiration or loss of water.

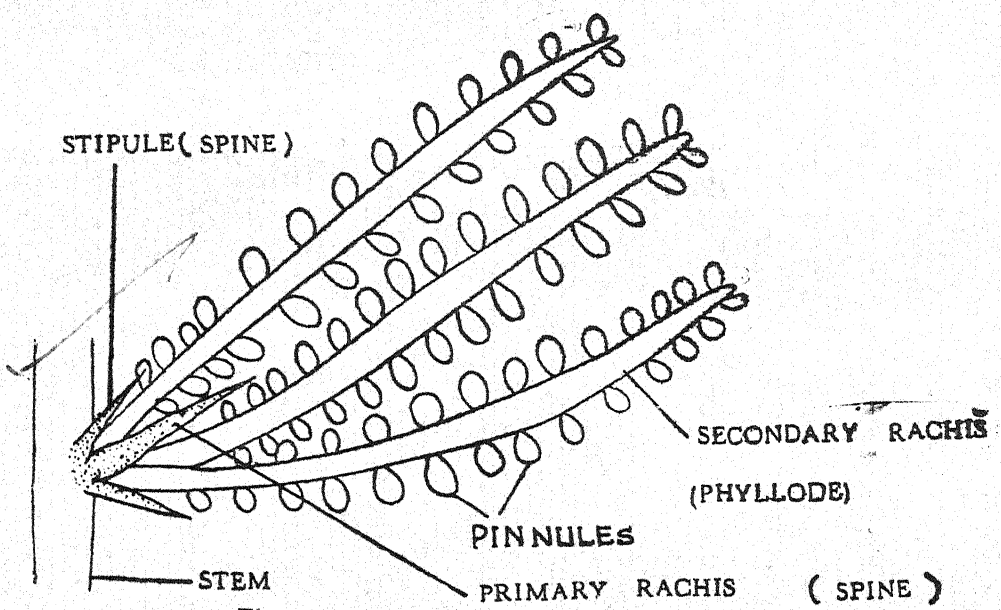


Fig. 20. A twig of *Parkinsonia* showing spiny stipules, spiny primary rachis and secondary rachis modified into phyllodes.

3. WINGED PETIOLE OF CITRUS

(1) This is a twig of *citrus* (lemon) of Rutaceae.

(2) The leaves are simple, exstipulate, petiolate, petiole winged, reticulate and unicostate.

(3) The spines are modified prophylls.

(4) The presence of spine shows its xerophytic character.

(5) Oil glands are present in the leaves.

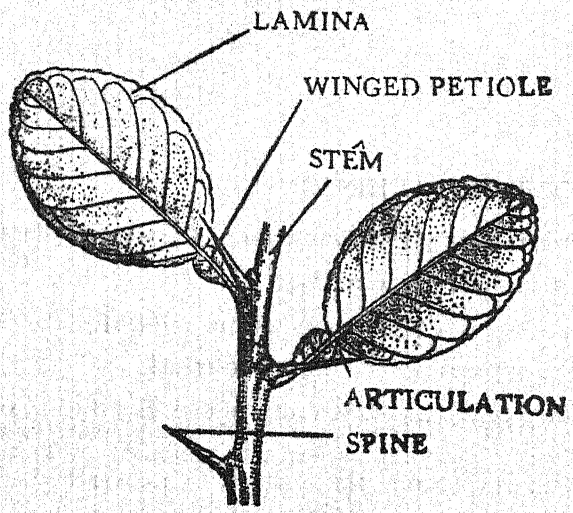


Fig. 21. A twig of lemon showing winged petiole and spiny prophylls.

4. RANUNCULUS & LIMNOPHILA SHOWING HETEROPHYLLY

(1) Both are hydrophytic plants showing two kinds of leaves (heterophylly).

(2) The submerged leaves are linear, ribbon-shaped or finely dissected.

(3) The aerial leaves are usually entire (slightly lobed or dentate).

(4) In *Limnophila heterophylla*, in submerged leaves, only the views of the aerial lamina are developed, the development of the remaining part being absent or arrested.

The reasons may be : (i) reduction in transpiration,
(ii) reduction in photosynthesis , (iii) hydostatic pressure ,
(iv) absence of drought , and (v) difference of habitat.

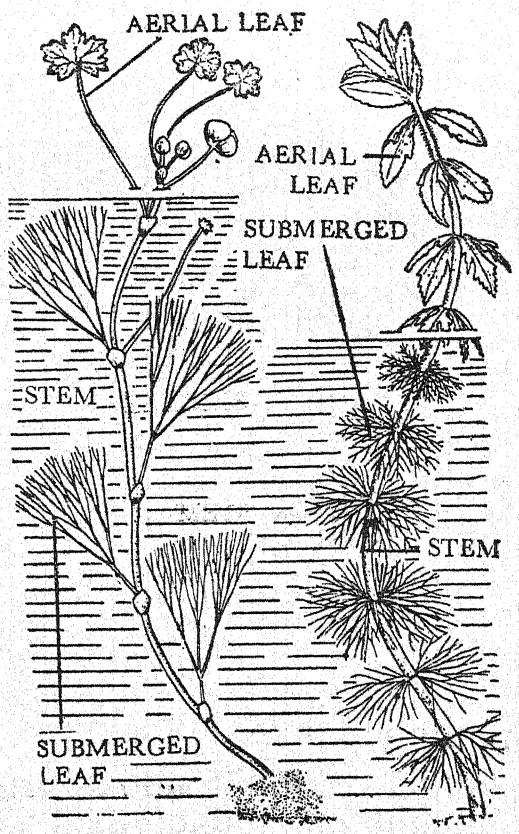


Fig. 22. Two hydrophytic plants showing heterophylly.

A. *Ranunculus aquatilis.*
B. *Limnophilla heterophylla.*

5. ADNATE STIPULES OF ROSE

(1) This is a twig of rose (*Rosa indica*) of Rosaceae showing a pair of adnate stipules.

(2) The leaf is a compound leaf.

(3) The leaf base bears a pair of lateral outgrowths or appendages called stipules.

(4) The two stipules are adnate or adherent to the sides of the petiole to a certain distance making the petiole more or less winged.

(5) Curved prickles are present on the stem which help in climbing.

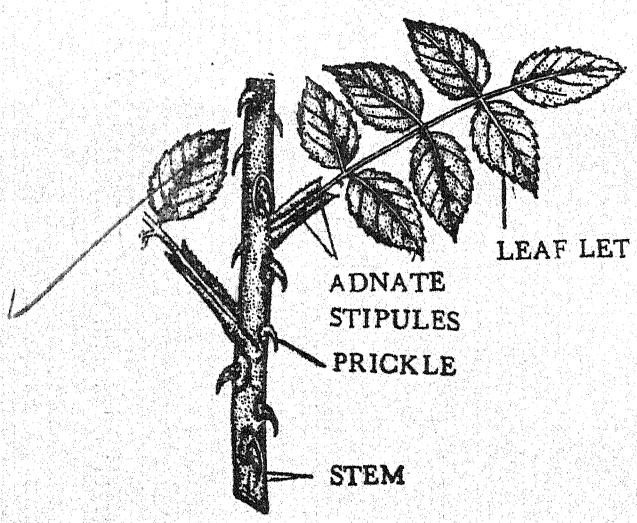


Fig. 23. A twig of rose showing adnate stipules and prickles.

6. LEAFLET HOOKS OF BIGNONIA

(1) This is a twig of *Bignonia unguiscali* (Bignoniaceae) showing leaflet hooks.

(2) The terminal leaflets are modified into curved claw-like structures.

(3) These structures are known as hooks.

(4) Hooks help the plant to climb.

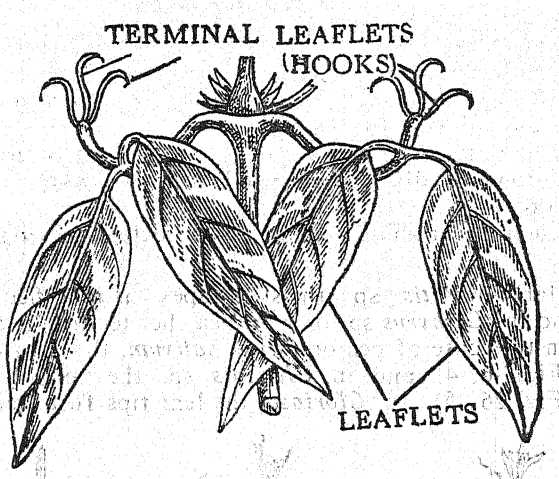


Fig. 24. A twig of *Bignonia* sp. showing hooks which are modified leaflets.

7. STIPELS OF DOLICHOS LABLAB

(1) This is a compound leaf of common bean (*Dolichos lablab*) of Papilionanceae (Fabaceae).

(2) The trifoliate imparipinnate leaf has a long petiole with swollen base called pulvinus.

(3) Stipule like small outgrowths or appendages are present on the base of the two sides of the leaflet bases.

(4) These structures are called *stipels* and are regarded as rudimentary leaflets.

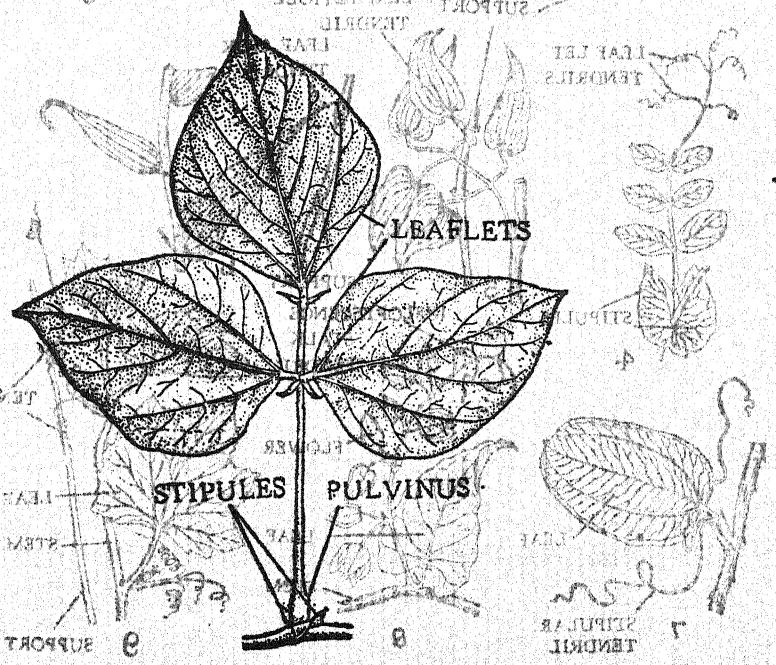


Fig. 25. A leaf of *Dolichos lablab* showing stipels and pulvinus.

TENDRILS

8. AXILLARY STEM TENDRIL

(1) This is a twig of Passion flower (*Passiflora*) of Passifloraceae with axillary stem tendrils (Fig 26, 1).

(2) The axillary stems are modified into thread-like structures. These structures grow spirally and encircle a support when it comes in contarct with the support.

(3) These thread-like structures are called *tendrils* and help the plant to climb.

Similarly in *Vitis* sp. the stem apex is modified into a tendril (Fig. 26, 2) and in *Lathyrus* sp. or wild pea the tendril is a modified leaf (Fig. 26, 3). In the case of pea or *Pisum sativum*, the leaflets are modified into tendrils (Fig. 26, 4) and in *Clematis* sp. the petioles are modified into tendrils (Fig. 26, 5). In *Gloriosa* the leaf tips form tendrils (Fig. 26, 6).

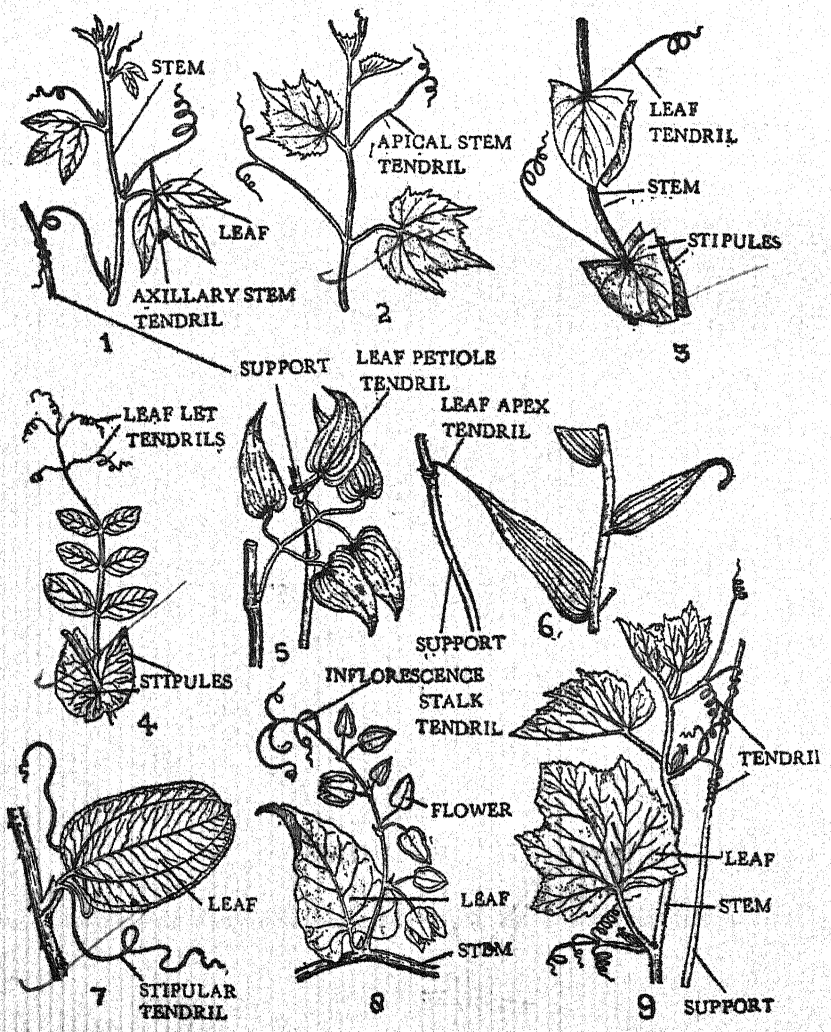


Fig. 26 (1-9) showing tendrils.

In *Smilax* stipules are modified into tendrils (Fig. 26, 7). In *Antigonon* the entire inflorescence axis is modified into tendril (Fig. 26, 8). In Cucurbitaceae (*Cucurbita*) the tendril has been interpreted variously. (Fig. 26 9).

1. Axillary stem tendril—*Passiflora*
2. Apical stem tendril—*Vitis* sp.
3. Leaf tendril—*Lathyous aphaca*
4. Leaflet tendril—*Pisum sativum*
5. Petiole tendril—*Clematis* sp.
6. Leaf apex tendril—*Gloriosa superba*
7. Stipular tendril—*Smilax*
8. Inflorescence axis tendril—*Antigonon*
9. Stem tendril (axillary)—*Cucurbita*

9. APICAL TENDRIL OF VITIS

(1) This is a twig of *Vitis quadrangularis* (Vitaceae) with apical tendrils (stem tendril).

(2) Tips of the sympodial branches are modified into long thread-like structures called apical tendrils.

(3) Later apical tendrils become lateral in position (opposing leaf).

(4) The tendrils help the plant to climb.

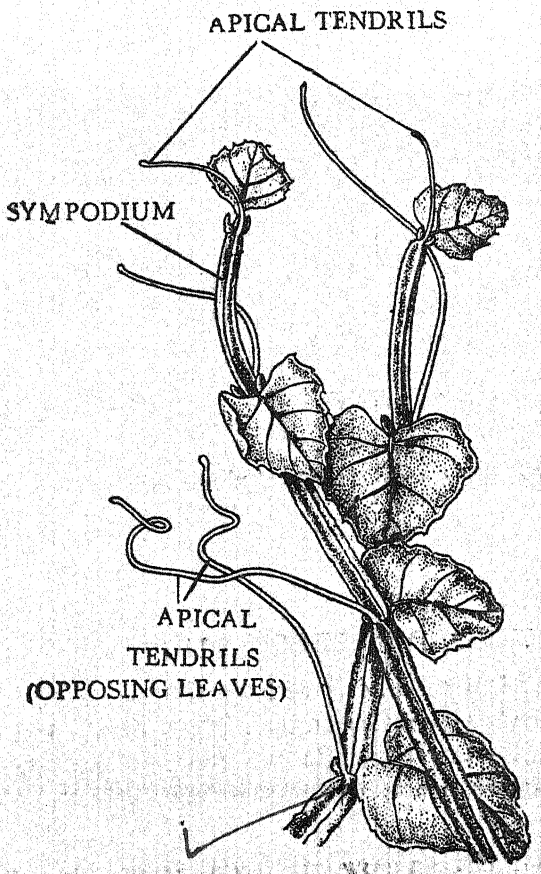


Fig. 27. Two twigs of *Vitis quadrangularis* showing apical tendrils.

ADVENTITIOUS BUDS

1. ADVENTITIOUS BUD OF BRYOPHYLLUM LEAF

(1) This is a leaf of *Bryophyllum* with *adventitious buds* present on leaf margins.

(2) The buds here are extra-axillary in position *i. e. epiphyllous* (when a bud grows from a position other than axil or apex, it is called an adventitious bud).

(3) When the margin of a leaf touches the ground, it forms young rooted plants which grow into new plants, as the buds are situated in the groves of the leaf margin.

(4) Adventitious buds help in vegetative propagation.

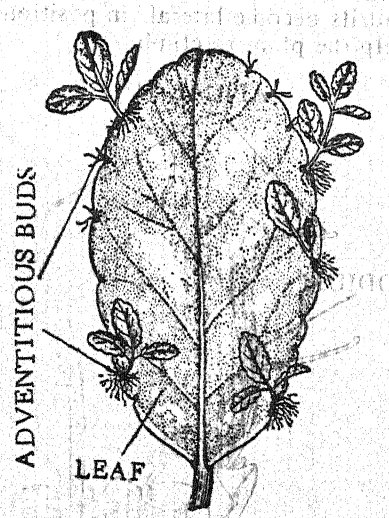


Fig. 28. A leaf of *Bryophyllum* with adventitious buds and new young plants.

2. ADVENTITIOUS BUD OF BEGONIA LEAF

(1) This is a leaf of *Begonia* with adventitious buds.

(2) These buds are present on the surface of the leaf lamina.

(3) These are extra-axillary in position and are epiphyllous.

(4) If incisions are made on the leaf, plantlings grow near the incisions.

(5) The plantlings can grow into new plants (as in *Bryophyllum*) and help in vegetative propagation.

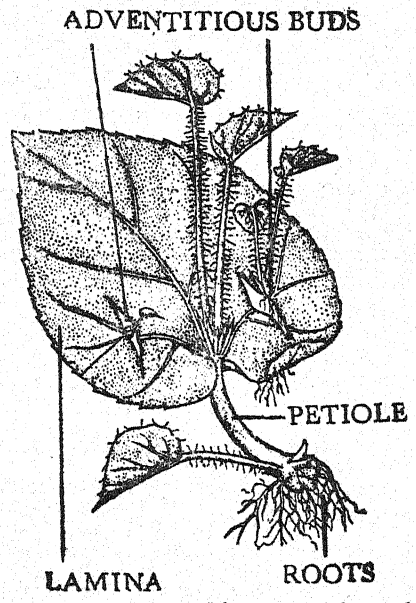


Fig. 29. A leaf of *Begonia* with adventitious buds.

3. ADVENTITIOUS BUD OF ROOT OF IPOMOEA

(1) This is a tuberous root of sweet potato (*Ipomoea batatus*) of Convolvulaceae with adventitious buds.

(2) The root is swollen due to the accumulation of food material. It is edible. The shape is not definite.

(3) Buds arising on the root are not normal in position, hence they are called adventitious buds.

(4) These buds help in vegetative propagation.

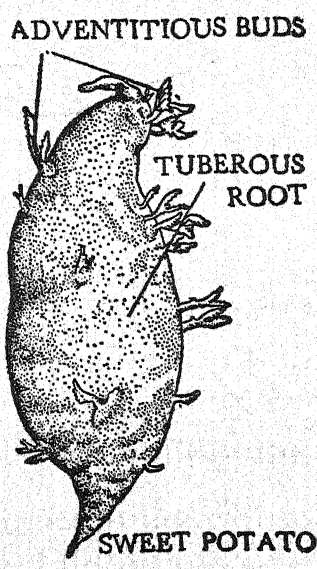


Fig. 30. A tuberous root of sweet potato with adventitious buds.

INFLORESCENCE

1. HEAD OR CAPITULUM OR ANTHODIUM OF COMPOSITAE

(1) The axis of the inflorescence is compressed into a flattened receptacle.

(2) A number of florets are arranged in centripetal manner on this receptacle.

(3) The whole head is surrounded by a number of green bracts known as involucre of bracts.

(4) Each floret is present in the axil of a scaly bract.

(5) The peripheral ligulate flowers are showy, usually female, larger in size and are termed *ray florets*. The central flowers are tubular, bisexual and smaller in size. These are called *disc florets*.

(6) In a single visit, a single insect can pollinate a number of flowers.

(7) This is the characteristic special type of racemose inflorescence of the Compositae (Asteraceae) family.

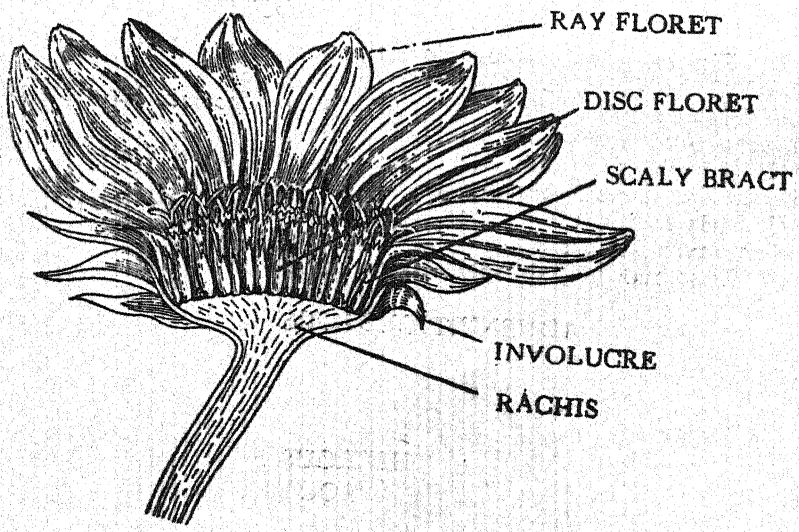


Fig. 31. A capitulum of sun flower cut longitudinally to show its different parts and arrangement of the *ray* and the *disc* florets on the receptacle.

2. HYPANTHODIUM OF FICUS

(1) In this special type of cymose inflorescence, the cup-shaped receptacle is formed by the condensation of the rachis of three cymes which are placed closely.

(2) There is a small opening on the top of the receptacle. This opening is known as ostiole.

(3) The flowers are arranged inside the receptacle in cymose groups.

(4) There are three types of flowers.

(3) The male flowers are present in the upper part of the hypanthodium, galls or sterile flowers in the middle and female flowers in the lower part.

(6) A number of flowers are pollinated by one insect (wasp) in a single visit.

(7) When an insect enters the cup through the ostiole, pollen grains are dusted onthe body of the insect as the male flowers are near the ostiole. The insect moves inside the cup pollinating the female flowers.

(8) This is a characteristic inflorescence of *Ficus* (Moraceae).

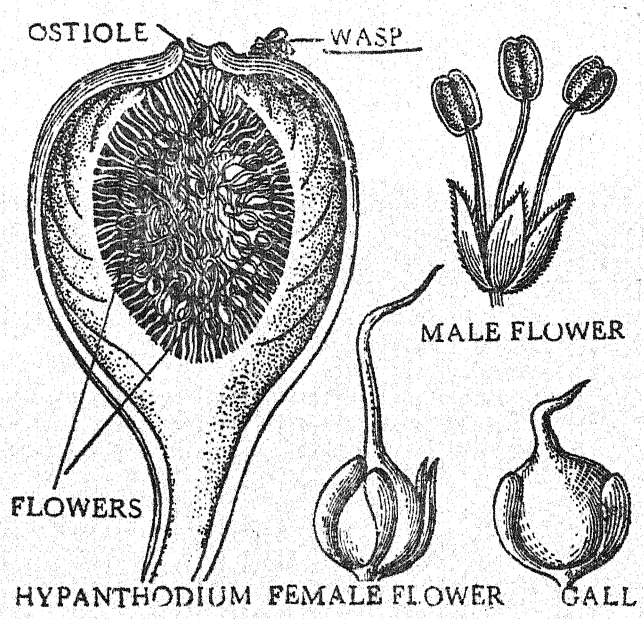


Fig. 32. A hypanthodium of *Ficus* cut longitudinally.

3. CYATHIUM OF EUPHORBIA

(1) This is a special type of cymose inflorescence of *Euphorbia pulcherrima* (*Euphorbiaceae*).

(2) A number of bracts fuse and form a cup-shaped involucre of bracts.

(3) The receptacle is convex and flowers are highly reduced and unisexual.

(4) There is a single female flower present on a long stalk and it is surrounded by a number of younger male flowers.

(5) The female flower is represented by a single pistil and the male flower is represented by a single stamen.

(6) Each flower has its individual pedicel and is present in the axil of a bracteole.

(7) Nectar or honey glands are present on the rim of the cup.

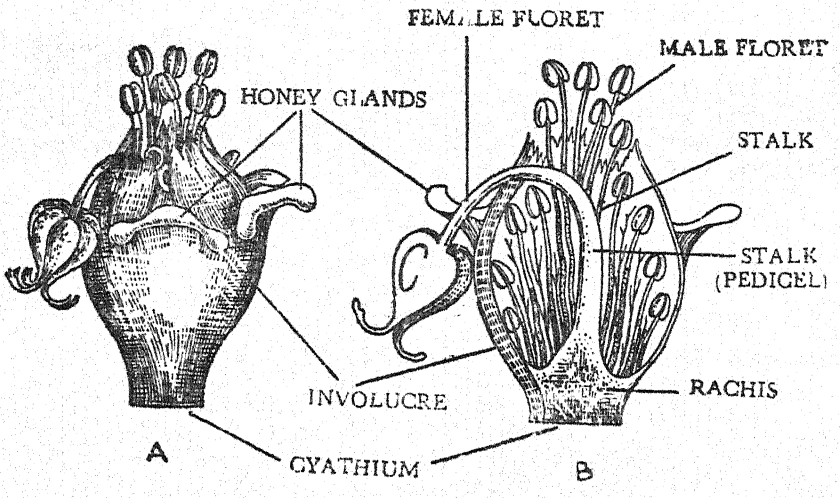


Fig. 33. Showing Cyathium of *Euphorbia pulcherrima*. A. showing Cyathium in external view, and B. showing male and female flowers in L. S.

4. VERTICILLASTER OF LABIATAE

(1) This is a twig of *Leonurus sibiricus* (Labiatae or Lamiaceae) showing verticillaster inflorescence.

(2) It is a condensed dichasial cyme.

(3) The stem is quadrangular and the leaves are opposite decussate.

(4) In the axils of the two leaves two inflorescences develop.

(5) The flowers are sessile and form a false whorl or *verticel* round the stem.

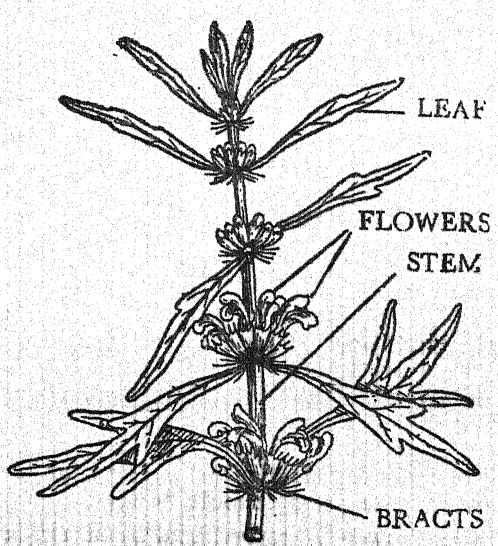


Fig. 34. A twig of *Leonurus* showing verticillaster inflorescence.

[*Leucas aspera* and *Ocsimum sanctum* are some other examples.]

5. SPADIX OF COLOCASIA (ARUM)

(1) This is the spadix inflorescence of *Colocasia antiquorum* (Araceae).

(2) Here the rachis is thick and fleshy. The flowers are covered by one spathy bract.

(3) The apical part of the axis bears no flowers and is called *appendix.*

(4) Below the appendix male flowers are present. The lower most part of the axis bears female flowers. In between male and female flowers, there is a part of the axis which bears sterile flowers.

(5) Spadix is a variation of spike.

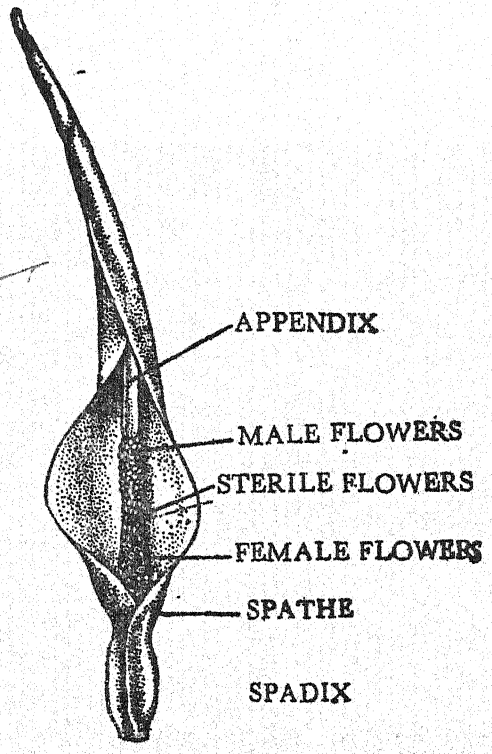


Fig. 35. Showing spadix of *Colocasia antiquorum.*

6. LEAF-LIKE SEPAL OF MUSSAENDA

(1) This is a flower of *Mussaenda frondosa* (Rubiaceae).

(2) One of the sepals does not look like a member of the calyx.

(3) It is large and vein-marked, like a leaf.

(4) It is pigmented like a petal and makes the flower showy and prominent.

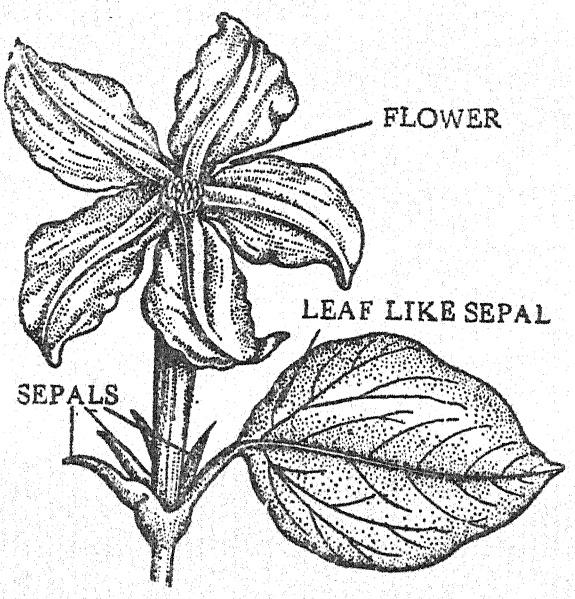


Fig. 36. A flower of *Mussaenda frondosa* showing a large leaf-like sepal in the calyx.

FRUIT

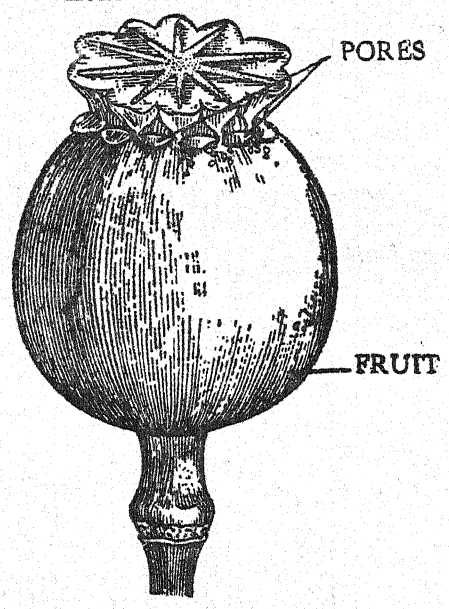
1. POROUS CAPSULE OF OPIUM POPPY

(1) This is a porous capsule of opium poppy (*Papaver somniferum*) of Papaveraceae.

(2) It is a dehiscent polycarpellary syncarpous fruit.

(3) Granular seeds are liberated by *censer mechamism* through a number of pores on the top of the ripe ovary.

(4) *Opium* (*Afim*) is extracted from the immature fruits. *Morphine* is obtained from opium which is used for relieving pain.



CAPSULE (POROUS) OF OPIUM POPPY

Fig. 37. A porous capsule of opium poppy.

2. NUT OF CASHEW-NUT

(1) This is a fruit (*nut*) of cashew-nut (*Anacardium occidentale*) of Anacardiaceae.

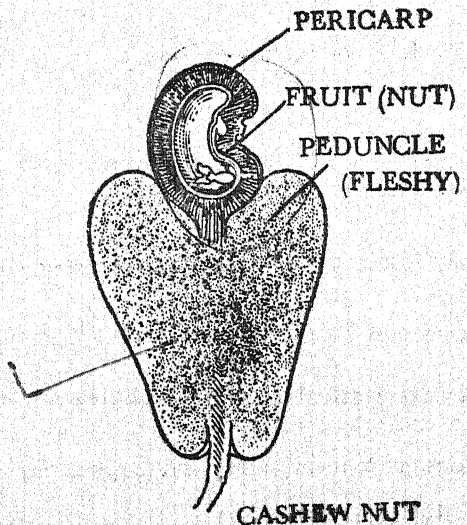
(2) This is a one chambered one-seeded indehiscent fruit.

(3) It develops from polycarpellary superior ovary.

(4) Pericarp is hard and woody.

(5) The edible part is mesocarp and the cotyledons.

(6) The peduncle is fleshy. It bears the nut.



CASHEW NUT

Fig. 38. L. S. of fruit of cashew-nut. The fleshy peduncle (below) bearing the nut above.

3. DRUPE OF MANGO

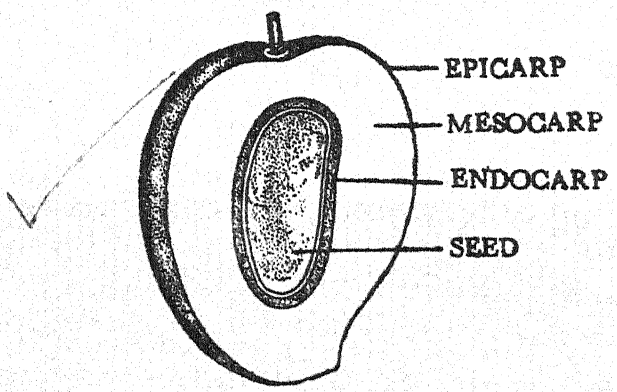
(1) This is a L. S. of a fleshy fruit of mango (*Mangifera indica*) of Anacardiaceae.

(2) This is a one-seeded indehiscent fruit and in L. S. shows epicarp, mesocarp and endocarp.

(3) The *epicarp* is skinny, the *mesocarp* is juicy and the *endocarp* is hard and stony. Because of its hard and stony endocarp, the fruit is also known as *stone fruit.*

(4) Mesocarp is the edible part of the fruit.

(5) The endocarp contains the seed.



DRUPE OF MANGO

Fig 39. L. S. of a fruit of mango.

[The fruit of *Cocos nucifera* (coconut) of Palmae is a fibrous drupe. The edible parts are endosperm and cotyledon.]

4. BERRY OF TOMATO

(1) This is a fleshy fruit of tomato (*Lycopersicum esculentum*) of Solanaceae.

(2) There is no hard part except for the seeds. The type of the fruit is *berry* or *bacca.*

(3) The seeds, at first, are attached to the highly swollen placenta but later on, become detached and are seen embedded in the pulp.

(4) The fruit develops from bicarpellary, syncarpous superior ovary.

(5) Calyx is persistent.

(6) The entire fruit is edible when ripe.

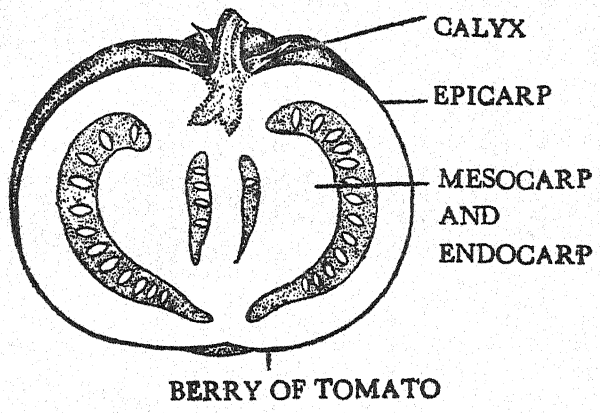


Fig. 40. L. S. of a tomato fruit.

5. POME OF APPLE

(1) This is a *pome* or *false* fruit of apple (*Pyrus malus*) of Rosaceae.

(2) The fruit develops from an inferior syncarpous ovary.

(3) The fruit is surrounded by a fleshy thalamus.

(4) Thalamus is the edible part.

(5) The epicarp and mesocarp are fleshy while the endocarp is cartilage-like.

(6) The endocarp contains the seed.

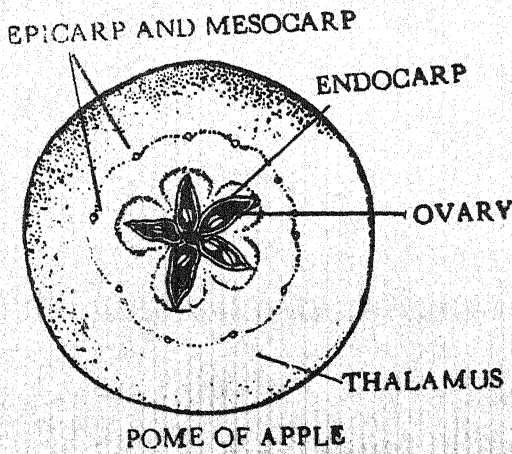
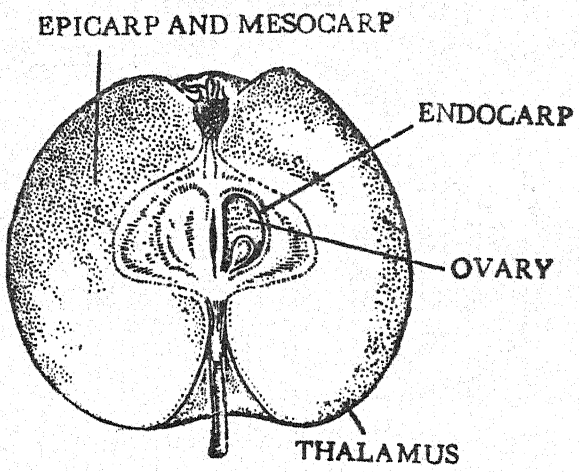


Fig. 41 (a). T. S. of a pome of apple.



POME OF APPLE

Fig. 41 (b). L. S. of a pome of apple.

6. SOROSIS OF PINEAPPLE

(1) This is a fruit of pine apple (*Ananas sativus*) of Bromeliaceae.

(2) Here the fruit is a *multiple* or *composite fruit* formed by the fusion of the rachis and all the floral parts.

(3) The ovaries are not so conspicuous and the edible part mostly consists of the rachis, perianth and the bracts.

(4) The seeds are very small.

(5) Each polygonal area on the surface represents a flower.

(6) *Bulbils* are also seen round the apical crown and the base of the fruit.

(7) These are modifications of whole buds.

(8) Bulbils help in vegetative propagation.

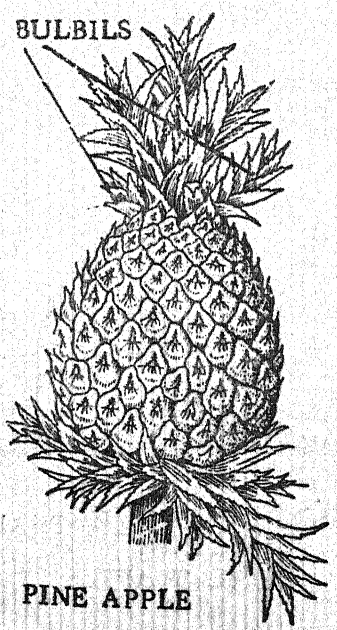


Fig. 42. A pine apple fruit with *bulbils*.

7. GRAIN OF MAIZE

1. The grain of maize (*Zea mays*) of Gramineae (Poaceae) is actually a fruit of the *caryopsis* type.

(2) The husks are short and loose so that the grains are exposed.

(3) The outer coating is formed by the fusion of the *pericarp* and the *seedcoat*. It is yellowish or red and cannot be separated from the kernel.

(4) Due to the presence of the pericarp covering, the micropyle and the hilum are not found.

(5) Endosperm is large and forms the bulk of the grain.

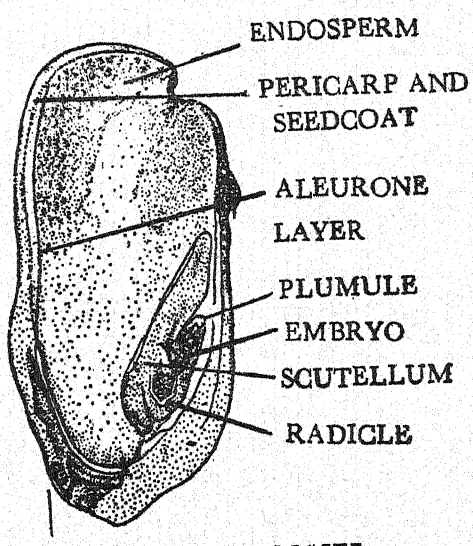
(6) The outermost layer of the endosperm contains mainly protein and is known as the *aleurone layer*. The inner part contains starch.

(7) The *embryo* is present towards the flat face of the grain.

(8) There is a shield-shaped structure on the upper side of the embryo called *scutellum*. It completely covers the endosperm.

(9) The *radicle* is covered by *coleorhiza* (root-sheath) and the plumule by *coleoptile*.

(10) Scutellum is actually the cotyledon and it absorbs the food material from the endosperm.



SEED (FRUIT) OF MAIZE

Fig. 43. L. S. of maize grain showing the different parts.

8. VIVIPARY IN RHIZOPHORA

(1) This is a twig of *Rhizophora* (a mangrove plant of Rhizophoraceae) showing viviparous germination.

(2) Viviparous germination is a peculiar type of germination. Here the seeds start germinating inside the fruit when the fruit is still attached to the parent plant.

(3) The embryo does not require any period of rest and grows and develops inside the seed within the fruit. The hypocotyle pierces the wall of the indehiscent fruit and when detached, they grow into new plants.

(4) *Vivipary* is an adaptation by which some halophytes (growing in saline soil) can avoid easily the retarding influence of high salt concentration on seed germination.

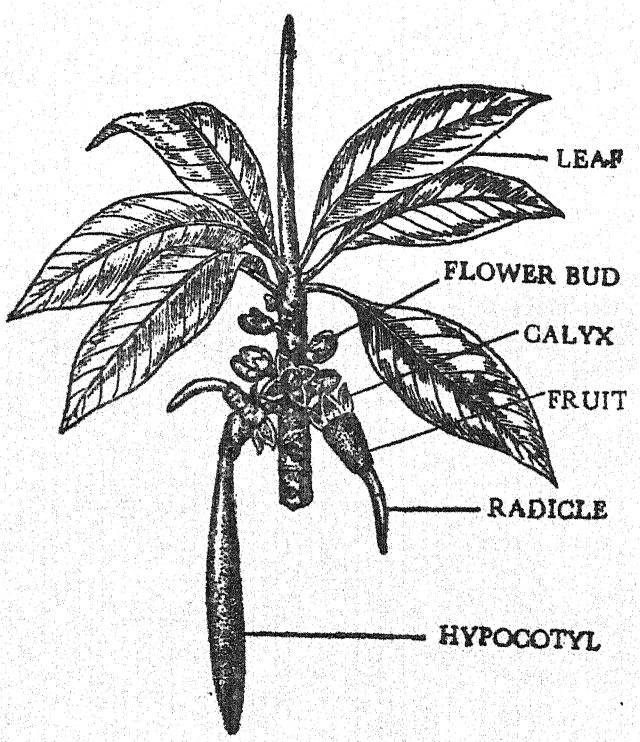


Fig. 44. A twig of *Rhizophora* showing viviparous germination.

MONSTROUS GROWTH OF SHOOT IN ROSE

(1) This is a twig of rose (*Rosa indica*) of Rosaceae showing development of the shoot beyond the flower.

(2) Here the growth of the thalamus is not limited by the carpels but the thalamus has grown beyond the gynoecium.

(3) The overgrown thalamus bears a leafy shoot above the flower.

(4) It serves as evidence in support of the view that the 'flower is a modified shoot'.

(5) The adnate stipules of the compound leaves are well marked.

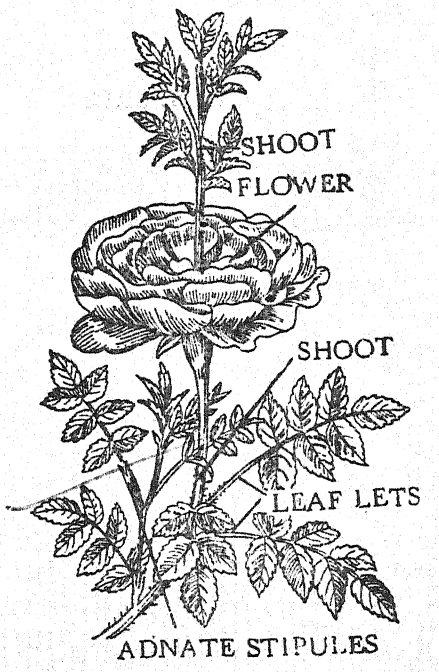


Fig. 45. Showing the development of the thalamus into a leafy shoot above the flower.

PARASITE

1. TOTAL STEM PARASITE

(1) This is a parasite dependent totally on the stem of its host and receiving the food from the host.

(2) The parasite is dodder (*Cuscuta reflexa*) of Convolvulaceae.

(3) This plant is a golden yellow coloured twiner and is devoid of leaves (even the embryo is deviod of cotyledons).

(4) The stem of the parasite twines round the host stem, sends haustorial structure in the host tissue which fixes the parasite on the stem of the host.

(5) The haustoria establish their connection with the xylem and phloem of the host and sometimes penetrate the pith also.

(6) Flowers are formed in clusters subtended by non-green bracts.

(7) The seed of *Cuscuta* gerimnates on soil but loses all connection with the soil after it gets a host.

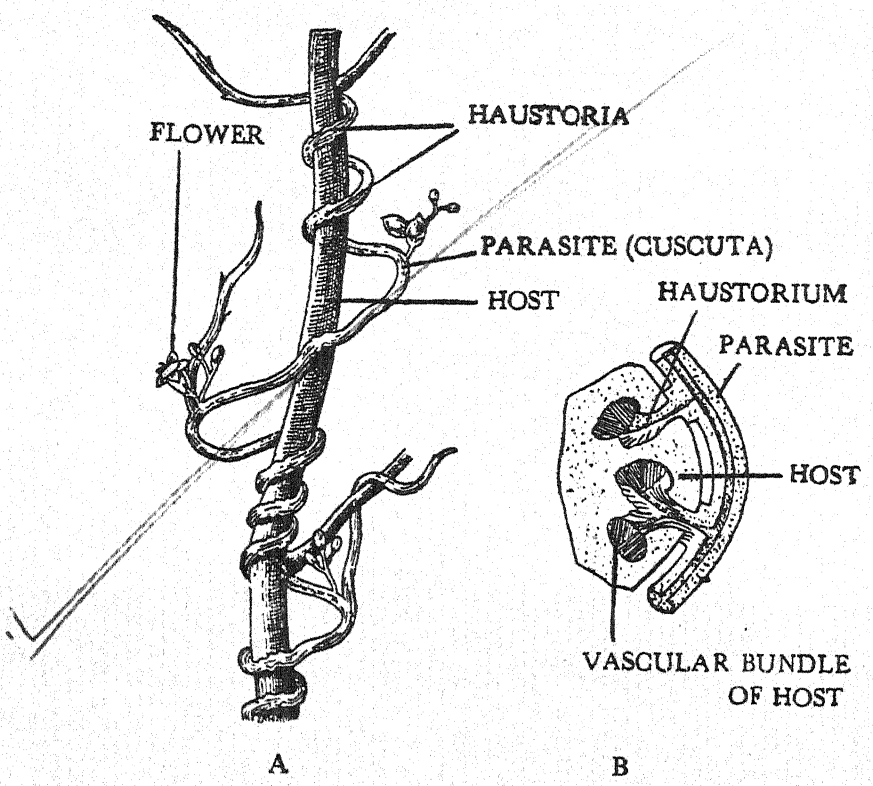


Fig. 46 (A). *Cuscuta reflexa*, a total stem parasite, twining the host.

(B). Haustoria of the parasite in intimate contact with the vascular bundle of the host.

2. TOTAL ROOT PARASITE

(1) The parasite is *Orobanche* sp. (Orobanchaceae).

(2) The host is a brinjal plant (*Solanum melonjena*) of Solanaceae.

(3) The parasite grows on the root of host plant.

(4) The parasite is a leafless plant.

(5) The seed of the parasite germinates only on contact with a root of the host plant and forms an underground tuber. Soon it forms an aerial inflorescence of coloured flowers subtended by brown bracts.

(6) The parasite gets the food from the host.

[Tobacco, tomato, potato, mustard etc. are its host plants].

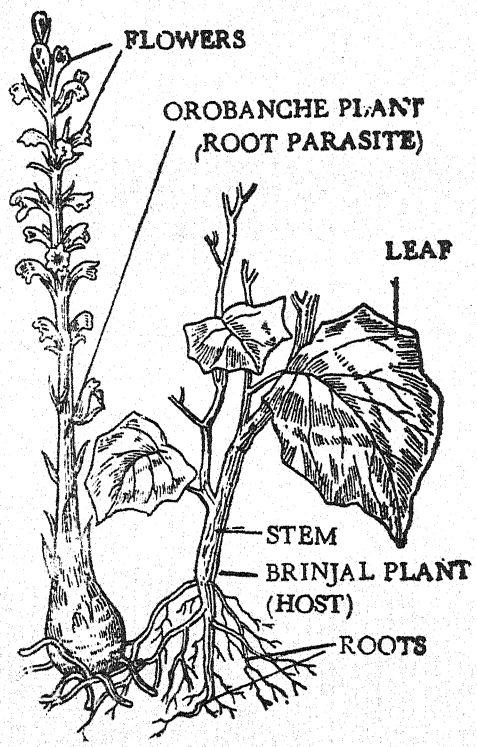


Fig. 47. An *Orobanche* plant, a parasite, growing on the root of a host plant (brinjal plant).

INSECTIVOROUS PLANTS

1. PITCHER OF NEPENTHES

(1) This is a pitcher plant (*Nepenthes*) of Nepenthaceae.

(2) Leaves of the plant *Nepenthes* form pitcher-like structures which catch insects. The insects are digested and thus this plant is called insectivorous or carnivorous plant.

(3) The lower part of the petiole is winged and the upper part is modified into a tendril-like structure. This may coil round a support so as to bear the weight of the pitcher formed above. The pitcher has a lid. The lid is coloured and attaracts insects.

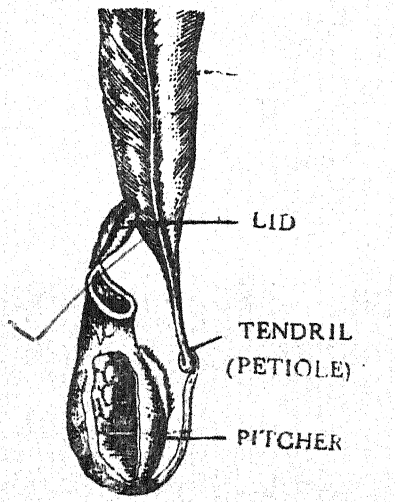
(4) Button-shaped glands are present on the inner walls of the pitcher. These glands secrete a fluid which is collected in the lower part of the pitcher.

(5) An insect trying to have a perch on it slips down partly because the edge of the pitcher is slippery and partly because it is curved. Moreover, due to the presence of some downward pointed hairs below the rim of the pitcher, the insect is trapped inside.

(6) Finally the proteinaceous part of the body of the insect is digested by the enzyme secreted from the glands.

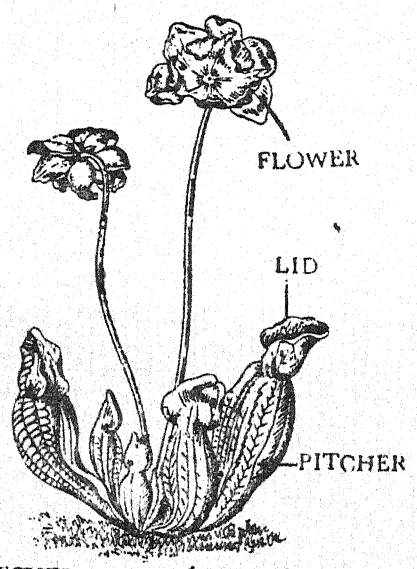
NOTE : 1. Different opinions have been expressed regarding the morphological nature of the parts of the pitcher. The winged part is considered as leafbase, while some others say that the winged part, the tendrillar part and the pitcher are parts of the petiole. The lid is said to be the whole lamina or only the apex of the lamina. One thing can be said safely that the pitcher is a part of the leaf.

2. In another genus *Sarracenia*, pitchers are formed in a rosette. Here the pitchers are seesile. There is a close resemblance with *Nepenthes*.



NEPENTHES (PITCHER PLANT)

Fig. 48. A pitcher of *Nepenthes*. A part of the wall is removed to show the fluid inside.



PITCHER PLANT (SARRACENIA)

Fig. 49. A Sarracenia plant showing pitchers forming a rosette.

2. GLANDULAR LEAF BLADE OF DROSERA

(1) This is a glandular leaf blade of *Drosera* (Droseraceae).

(2) The upper surface of the leaf blade is covered by a number of glandular hairs called *tentacles*.

(3) The tentacles secrete a sticky fluid. The drops of this fluid shine in sun light like the drops of dew hence the name 'Sundew' for *Drasera*. These shining drops can attract insects.

(4) An insect coming to the leaf surface gets trapped due to the sticky fluid and the tentacles.

(5) The tentacles are sensitive to protein. They bend towards the insect and trap it.

(6) Ultimately the insect is killed and the protein substance is digested by the enzyme secreted by the glands.

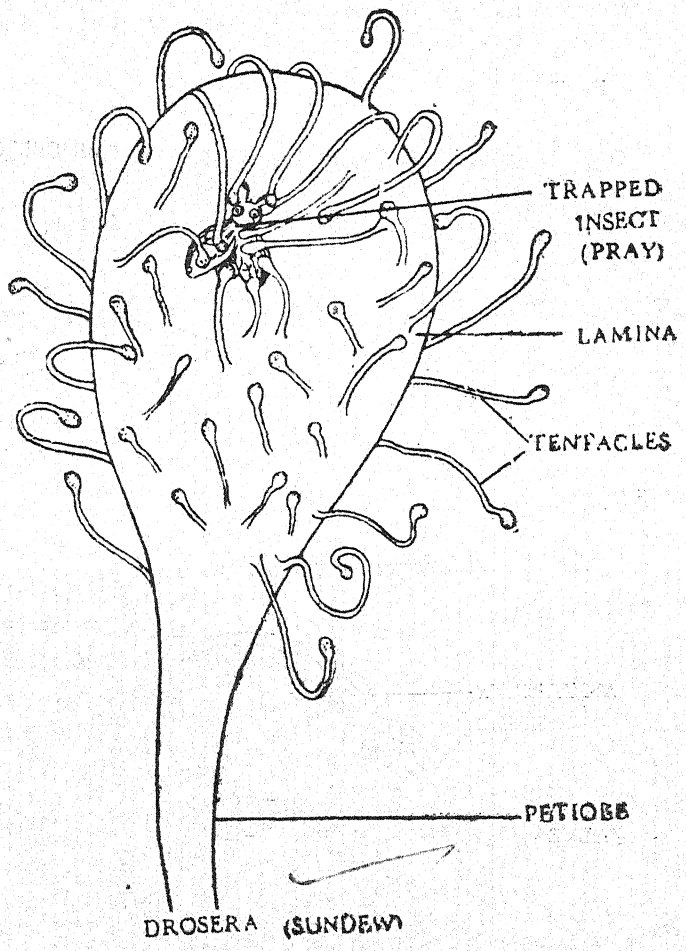


Fig. 50. A leaf of *Drosera* showing a trapped insect. The tentacles are bent over the body of the insect.

3. BLADDER OF UTRICULARIA

(1) This is a part of the plant *Utricularia* or *Bladderwort* of Utriculariaceae bearing a number of bladders.

(2) *Utricularia* is a free floating rootless hydrophytic weed.

(3) The leaves are finely dissected and look like green roots.

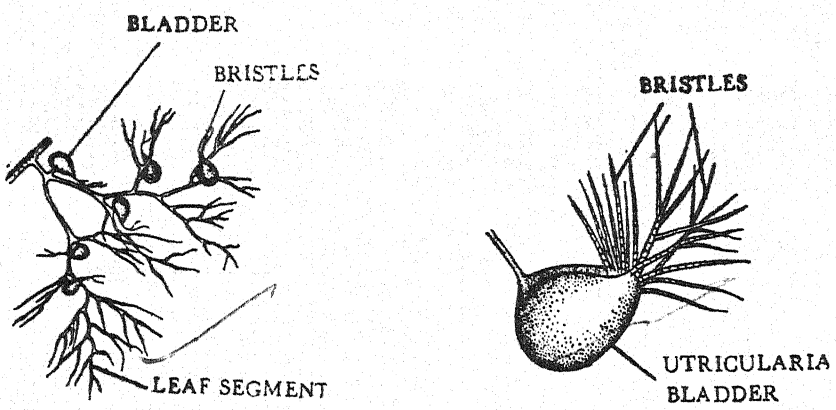
(4) A number of leaf segments are modified into *bladders* or *utricles.*

(5) Digestive glands are present on the inner walls of the bladder.

(6) A valve door is present at the opening of the bladder. Long branched hairs or bristles are also present.

(7) The valve door can be opened from outside but not from inside the bladder.

(8) Even a minute water animal can open the valve door by pushing the bristles. Water enters the bladder carrying the organism. Finally the prey is killed and digested.



UTRICULARIA (BLADDER WORT)

Fig. 51. Showing *Utricularia* bladders.

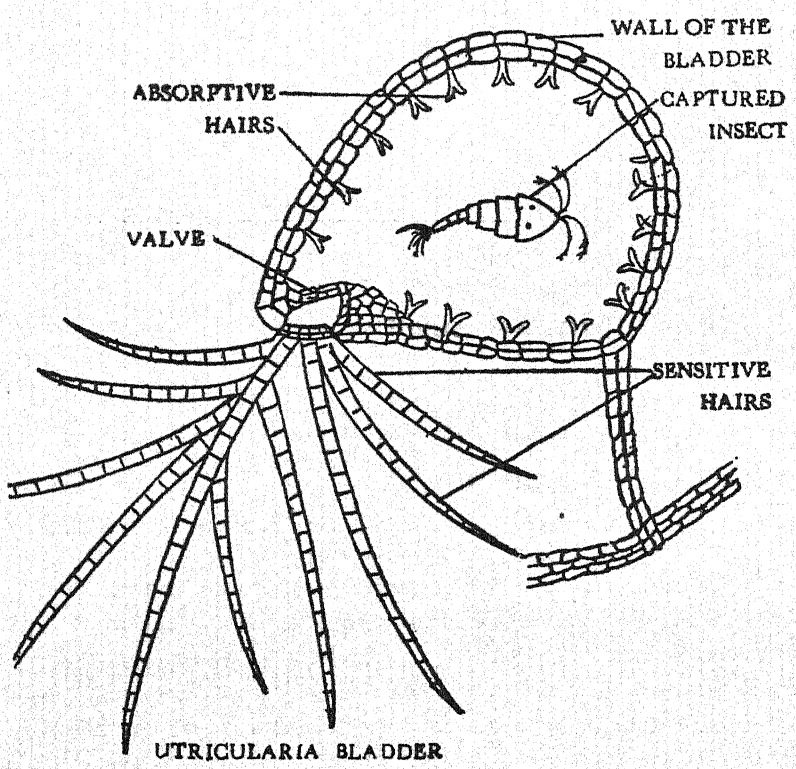


Fig. 52. Section of a bladder showing absorptive hairs and a captured prey.

4. TRIGGER HAIRS OF DIONOEA

(1) This is an insectivorous plant known as *Dionoea* or *Venus' Fly-trap* (Droseriaceae).

(2) The leaves of the plant are radical and occur in a rosette.

(3) Each leaf has a winged petiole and the lamina is notched at the apex. The leaf margins are provided with marginal hairs or pointed teeth. The margin is slightly incurved.

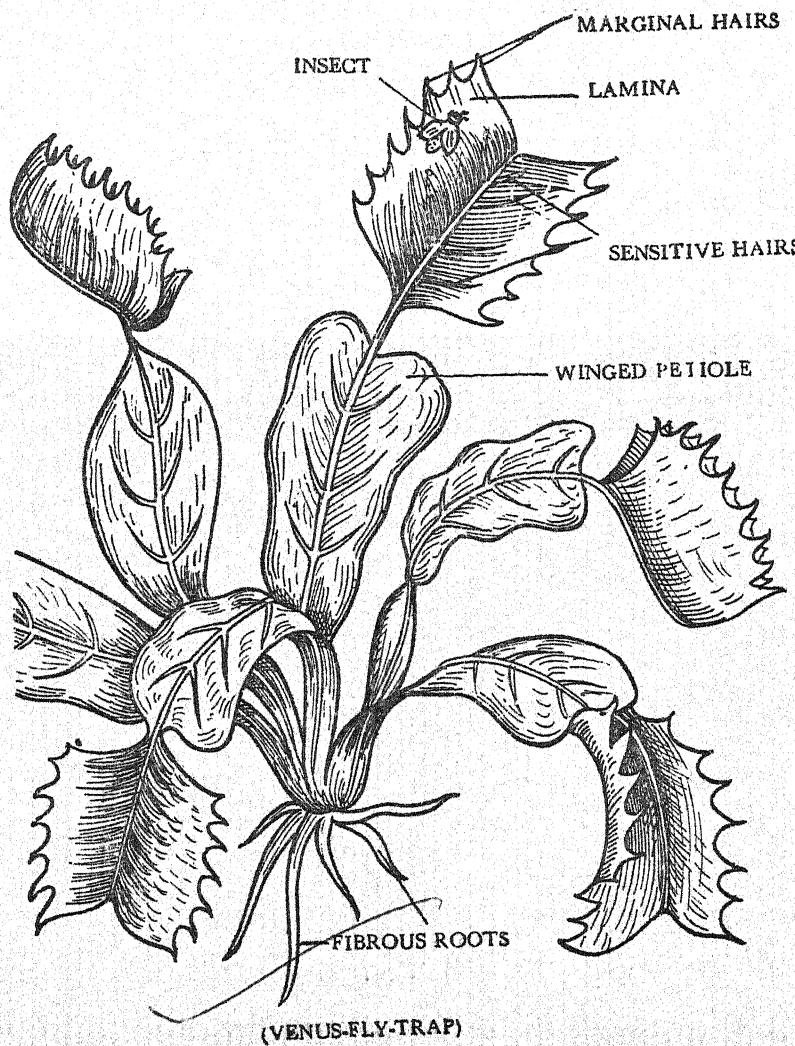


Fig. 53. A plant of *Dionoea* showing habit.

(4) There are six sensitive hairs (three on each half of the lamina) called *trigger hairs* on the upper surface of the lamina. A number of glands (reddish in colour) are also present.

(5) When an insect comes and touches the trigger hair, the leaf closes like a 'rat trap' and digestive enzyme is secreted by the glands.

(6) The proteinaceous substance is digested and the leaf reopens only when the process of digestion is complete.

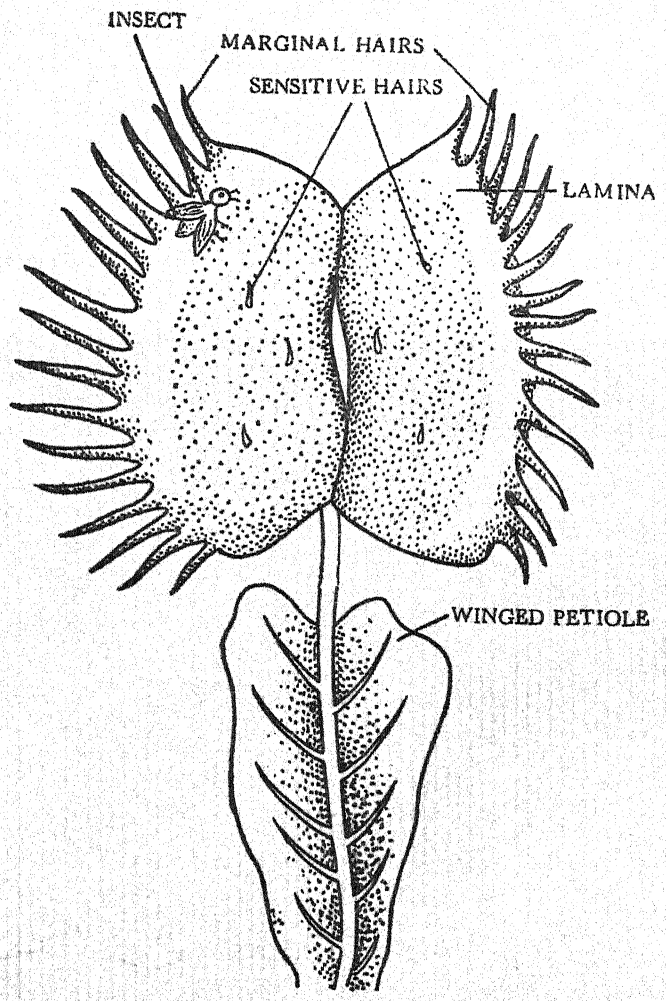


Fig. 54. A leaf of *Dionoea* showing sensitive trigger hairs

CHAPTER 2

Anatomy

STEM OF CUCURBITA (Cucurbitaceae)

Prepare a double stained glycerine mount of the t. s. and l. s. of stem of *Cucurbita*. Examine and sketch under low and high powers of the microscope. Identify giving reasons.

(1) In a transverse section the stem shows distinct ridges and furrows. Thus it is wavy in outline.

(2) There are two rings of vascular bundles (5 vascular bundles in each ring).

(3) The vascular bundles of the outer ring are smaller in size and are present against the ridges, called leaf-trace bundles.

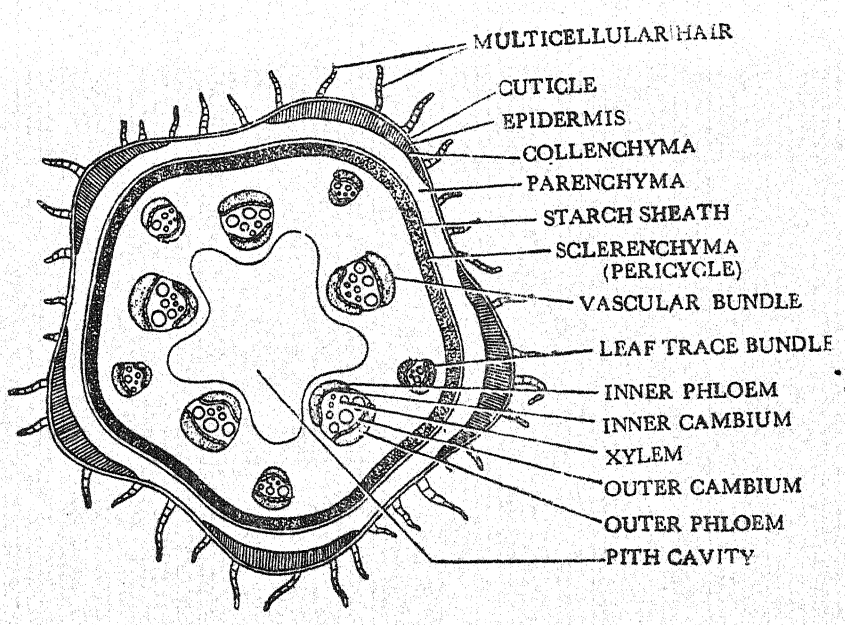


Fig. 55. T. S. of a young stem of *Cucurbita* (diagrammatic).

(4) The bundles of the inner ring are larger in size and are present against the furrows.

(5) In the centre of the stem there is a hollow pith formed due to disintegration of the pith cells.

After careful observation under the microscope, the *Cucurbita* stem shows the following arrangement of the different tissues:

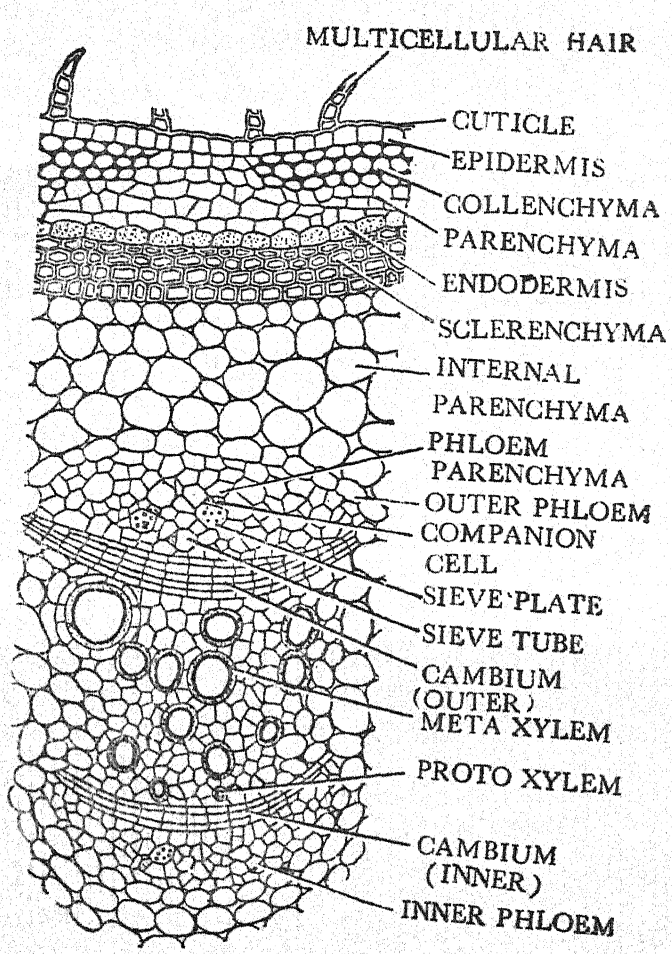


Fig. 56. A portion of the t. s. of *Cucurbita* stem showing the different tissues.

(1) The outermost layer is *epidermis.* It is single layered and composed of tabular cells which show end on end attachment. The outer walls of the epidermal cells are thickened with cuticle. Stomata are present here and there and multicelluler epidermal outgrowths or hairs are also present.

(2) *Cortex* is seen internal to the epidermis and is differentiated into three zones. The outer cortex is collenchymatous and is present at the ridges. They may contain *chloroplasts.* Against furrows hypodermis is parenchymatous and the cells contain chloroplasts. The middle cortex is parenchymatous and may contain chloroplasts. The inner cortex is single-layered made up of barrel-shaped cells containing starch grains. These cells are joined by their radial walls. This layer is called the *endodermis* or starch sheath.

(3) Internal to the endodermis is the *stele* or the central cylinder.

(4) Just internal to the endodermis is the *pericycle*. In the pericycle patches of *sclerenchyma* are present separated by multilayered *parenchyma*. Internal to it, two rings of *vascular bundles* are present. Parenchyma cells also occur in between the vascular bundles. These are known as internal parenchyma.

(5) Each vascular bundle is *bicollateral*. A bicollateral vascular bundle shows two patches of phloem (outer phloem and inner phloem) and two strips of cambium (outer cambium and inner cambium) on either side of the xylem.

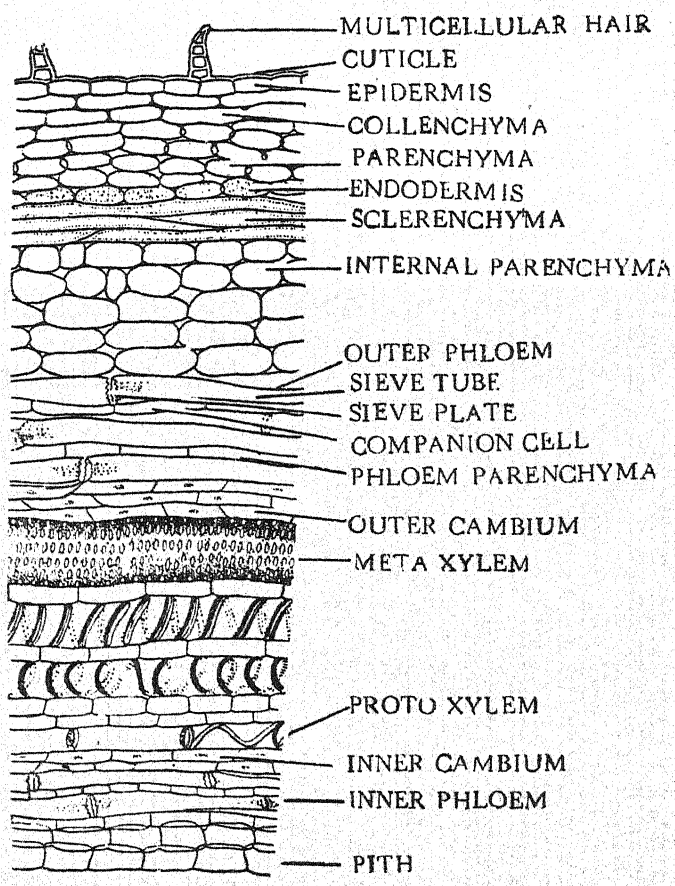


Fig. 57. A portion of the longitudinal section of the stem of *Cucurbita* showing the arrangement of the different tissues.

(6) The outer phloem is composed of *sieve tubes*, companion cells and phloem parenchyma. Sieve plates are noted here and there. They

are present at the end walls of the sieve tubes and are obliquely placed. Xylem is composed of metaxylem and protoxylem. The metaxylem vessels are very large-sized and show *pitted* thickenings. The protoxylem, present in the centre, have narrower cavities and show *spiral* and *annular* thickenings. Tracheids and fibres are either few or altogether absent. Xylem parenchyma cells are found in abundance. The cambium occurs on either side of the xylem. The cells of the outer cambium are rectangular, thin walled, joined by their radial as well as tangential walls. It is multilayered. The cells of the inner cambium are smaller and curved. The inner phloem resembles the outer phloem but it is not so massive.

(7) Secondary xylem and secondary phloem are seen in older stems.

(8) In the centre of the stem there is a large cavity formed due to disintegration of the pith cells.

Identification

1. Wavy outline of the stem (five ridges and five furrows).
2. Presence of vascular bundles in two rings of five bundles each.
3. Each vascular bundle is bicollateral.
4. Vascular bundle open.
5. Small cortex & large pith (pith cavity).
6. Presence of photosynthetic tissue in the cortex.
7. Presence of stomata and multicellular hairs on the epiderims.

STEM OF CALOTROPIS (Asclepiadaceae)

Prepare a double stained glycerine mount of the t. s. of stem of *Calotropis procera*. Examine and sketch under low and high powers of the microscope. Note its special features and identify it giving reasons.

(1) In a transverse section the outline of the stem is almost circular.

(2) It shows epidermis, cortex and stele.

(3) The epidermis is single layered. The cells are tabular. Here and there stomata are also seen. There is a thick cuticle on the outer walls of the epidermal cells. Deposition of waxy substances is marked on the epidermis.

(4) Cortex is differentiated into outer lacunate collenchyma, middle massive parenchyma and inner single layered endodermis containing starch grains.

(5) Pericycle is massive and is composed of patches of sclerenchyma and parenchyma.

(6) The vascular bundles are *collateral, endarch open* and arranged in a ring. Bundles are compactly arranged with intervening ray cells and intrastelar ground tissues.

(7) There is a large parenchymatous pith in the centre of the stem.

(8) Internal to the protoxylem, in the pith, patches of *internal* or *intraxylary phloem* are also present. This is a characteristic feature of the stem of *Calotropis*.

(9) Latex cells are also seen in the cortex and the pith.

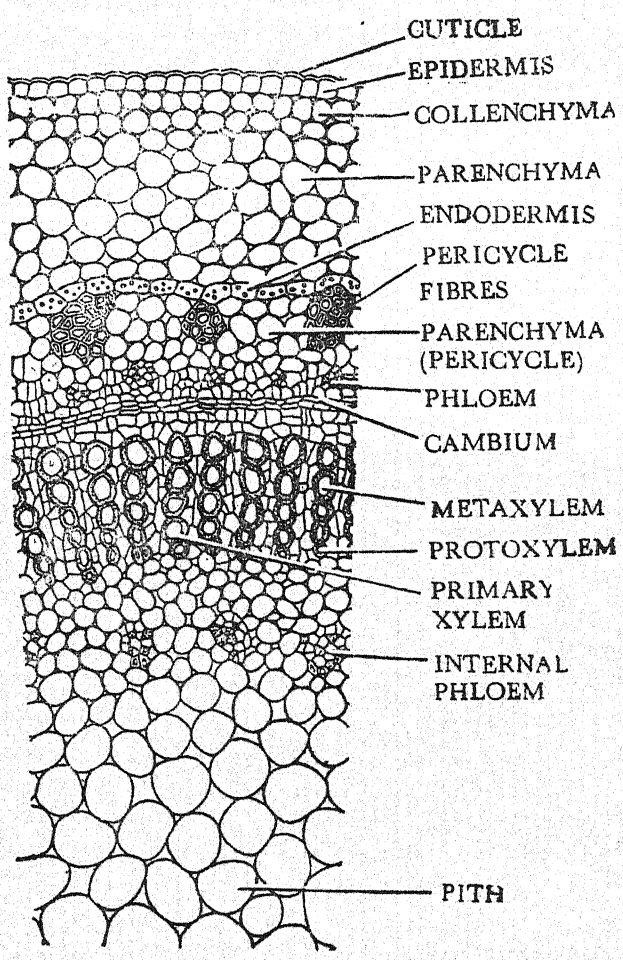


Fig. 58. A portion of the t. s. of the stem of *Calotropis procera* showing *intraxylary phloem*.

MONOCOT STEM OF ASPARAGUS (Liliaceae)

Prepare a double stained glycerine mount of the transverse section of the stem of *Asparagus*. Examine and sketch under low and high powers of the microscope. Note its charcteristic features and identify giving reasons.

(1) The outline of the stem in a t. s. is roughly circular.

(2) The outermost layer, the epidermis, is composed of thin-walled cells with thickening of cuticle on the upper tangential walls. Stomata are also seen.

(3) Internal to the epidermis is multilayered parenchyma containing chloroplasts (chlorenchyma) which is green and photosynthetic in nature. The cells are losely arranged.

(4) Internal to this zone there is multilayered sclerenchyma The cells are thick-walled and compactly arranged.

(5) Internal to sclerenchyma, vascular bundles are present embedded in, parenchymatous ground tissue.

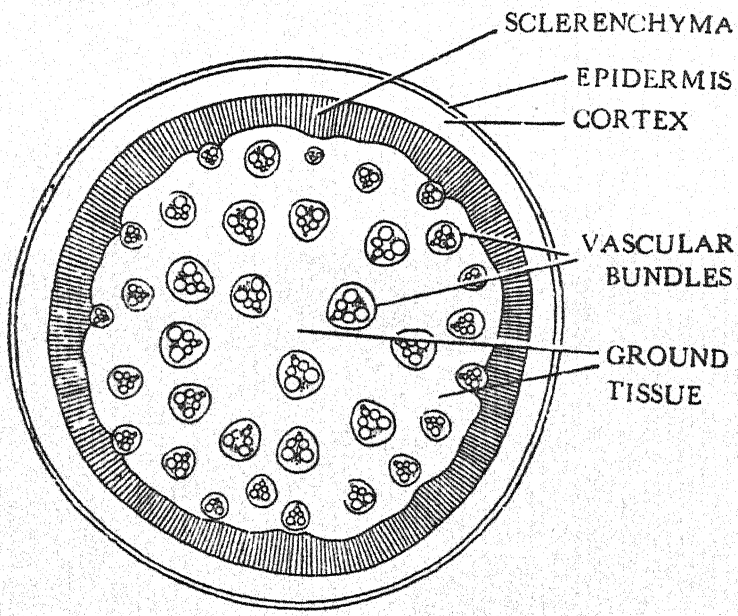


Fig. 59. Diagrammatic structure of .t s. of stem of *Asparagus*.

(6) The vascular bundles are indefinite in number and are scattered.

(7) Each vascular bundle is collateral, endarch, conjoint and closed (cambium absent). There is no bundle sheath.

(8) Phloem is present between two arms of the xylem and is composed of sieve tubes and companion cells.

(9) Xylem is 'V' shaped and is made up of vessels, tracheids and xylem parenchyma. The protoxylem elements point towards the centre (endarch).

(10) The stele is atactostelic type.

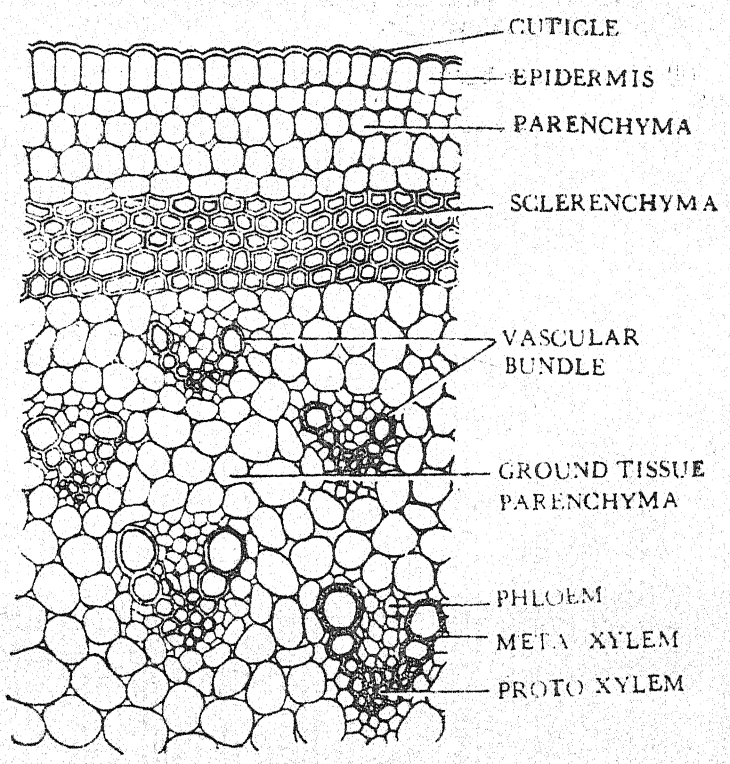


Fig. 60. A portion of the section under high power of the microscope.

Identification

It is a *monocot stem* because of the following characters :

1. There is no distinction between the cortex and the pith.
2. Vascular bundles are numerous (indefinite) and scattered.
3. Each vascular bundle is conjoint, collateral, closed and endarch.
4. Xylem is 'V' shaped.

Xerophytic Characters

1. Presence of thick cuticle on upper tangential walls of the epidermal cells.

2. Presence of chlorenchyma and sclerenchyma in the ground tissue out side the vascular bundles.

MONOCOT STEM OF MAIZE (Graminaceae)

(1) In a t. s. the outline of the stem is almost circular.

(2) The epidermis is single layered, and is composed of thinwalled parenchymatous barrel-shaped cells. Cuticle is present on the upper walls of these cells.

(3) Internal to epidermis is the hypodermis. It is composed of 3—4 layers of sclerenchymatous cells.

(4) The vascular bundles are embedded in the parenchymatous ground tissue.

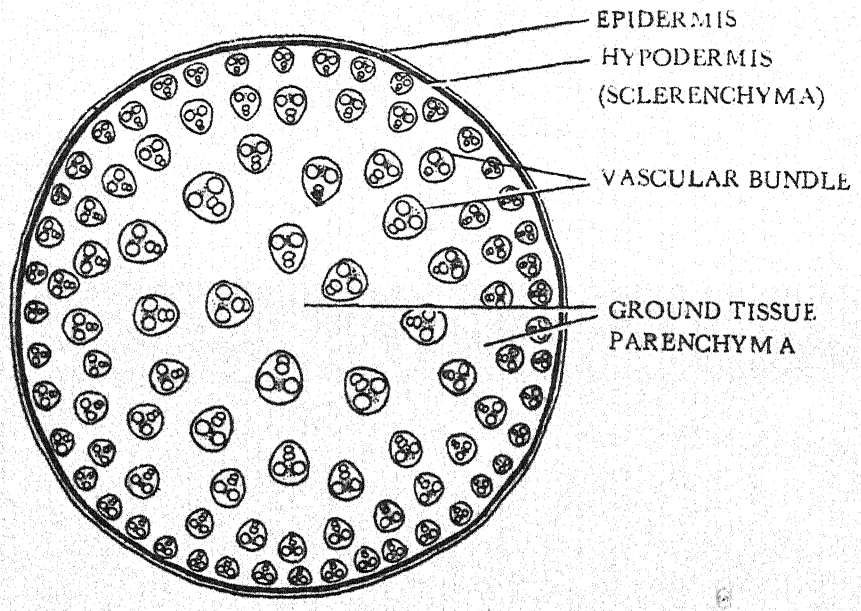


Fig. 61. Diagrammatic sketch of the t. s. of stem of maize.

(5) Vascular bundles are scattered, indefinite in number (numerous), oval, conjoint, collateral, closed and endarch. The vascular bundles present in the central region are larger in size.

(6) Sclerenchymatous bundle sheath is present surrounding each vascular bundle.

(7) Phloem shows only sieve tubes and companion cells. Phloem parenchyma is absent.

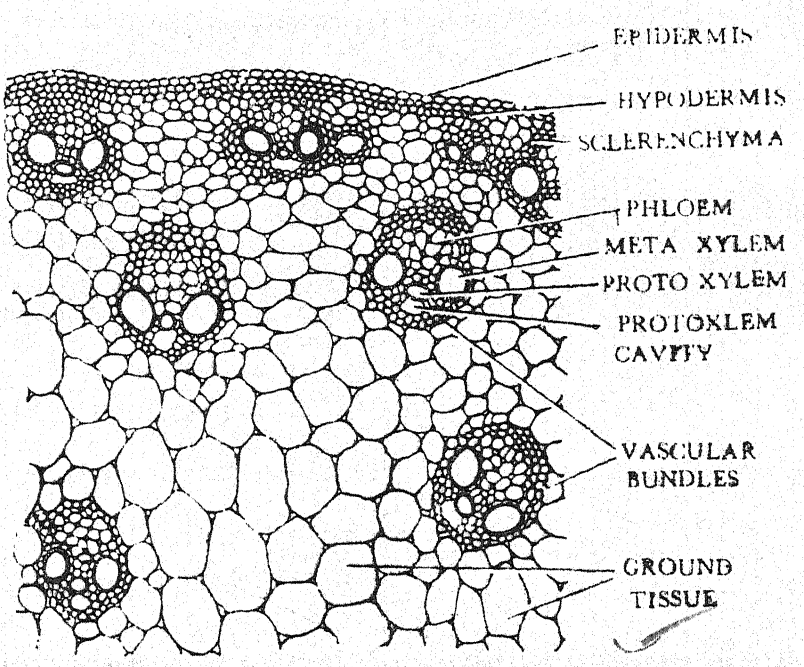


Fig. 62. A portion of the t. s. of the stem under the microscope.

(8) Xylem is composed of vessels, tracheids and xylem parenchyma. It is 'V'-shaped or 'Y'-shaped. Lysigenous cavity (formed by dissolution of protoxylem cells) is present below protoxylem on either side of which cells of phloem parenchyma are present.

(9) Stele is an atactostele.

Xerophytic Characters

1. Presence of thick cuticle.
2. Presence of sclerenchyma.
3. Presence of lysigenous cavities.
4. Presence of bundle sheath (sclerenchyma) surrounding the vascular bundle.

Identification

It is a monocot stem because ;

1. There is no distinction between the cortex and the pith. Only ground tissue is present embedding the vascular bundles.
2. Vascular bundles are indefinite, scattered, conjoint, collateral, closed and endarch.
3. Xylem is 'V'-shaped or 'Y'-shaped.
4. Presence of sclerenchyma sheath of the vascular bundles.
5. Presence of lysigenous cavity.

SCAPE OF CANNA (Cannaceae)

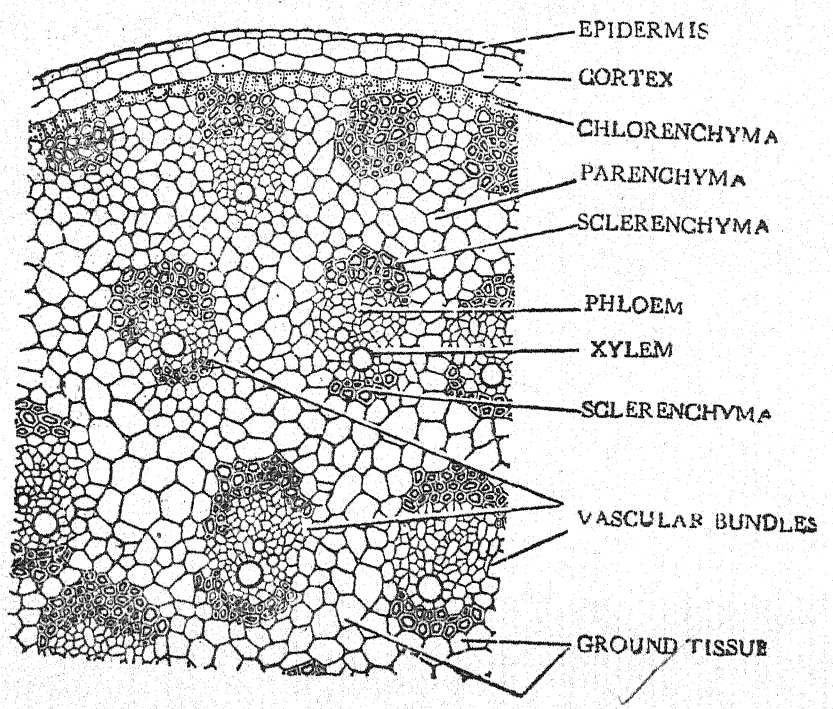


Fig. 63. A portion of the scape of *Canna*.

(1) In a transverse section the out line of the scape of *Canna* is almost circular.

(2) It shows epidermis, ground tissue and vascular bundles.

(3) Epidermis is the outermost layer and it is cuticularised.

(4) Internal to epidermis is parenchyma. It is referred as cortex.

(5) Internal to cortex is chlorenchyma containing chloroplasts. Patches of sclerenchyma are attached to this layer.

6. The vascular bnndles are embedded in parenchymotous ground tissue.

(7) The vascular bundles are indefinite in number, scattered, conjoint, collateral. closed with small amount of xylem and phloem.

(8) Sclerenchyma patches are present on the outer and inner sides of the vascular bundles, the patch on the inner side being proportionately smaller.

Thus the internal structure of the scape (floral axis) of *Canna* resembles with a monocotyledonous stem, though a bit different.

MONOCOT STEM OF DRACAE NA (Liliaceae)

Prepare a double stained glycerine mount of the t. s. of stem of *Dracaena*. Examine and sketch under low and high powers of the microscope. Note the abnormal secondary growth and identify giving reasons.

(1) In a transverse section the outline of the stem is circular.

(2) It shows epidermis, ground tissue and vascular bundles.

(3) The primary vascular bundles are indefinite in number, scattered, *amphivasal* (xylem surrounding phloem) or conjoint, collateral, closed and endarch.

(4) The primary vascular bundles are embedded in the parenchymatous ground tissue.

(5) Just out side the primary vascular bundles, in the ground parenchyma, secondary vascular bundles are seen embedded in the conjunctive tissue.

(6) Both the conjunctive tissue as well as the secondary vascular bundles are formed by abnormally formed cambium (as normally no cambium is present in the monocotyledons).

(7) This cambium is not only abnormal in position but abnormal in activity also as it first forms *amphivasal* secondary vascular bundles embedded in conjunctive tissue internally and lateron only parenchyma cells externally.

(8) At a later stage the conjunctive tissue becomes thick-walled.

(9) In the extreme periphery, the parenchyma cells become meristematic, form radially arranged layers of cells, undergo suberisation and differentiate into cork cells known as *storied cork*.

(10) The epidermis is broaken at places due to the formation of the secondary tissue.

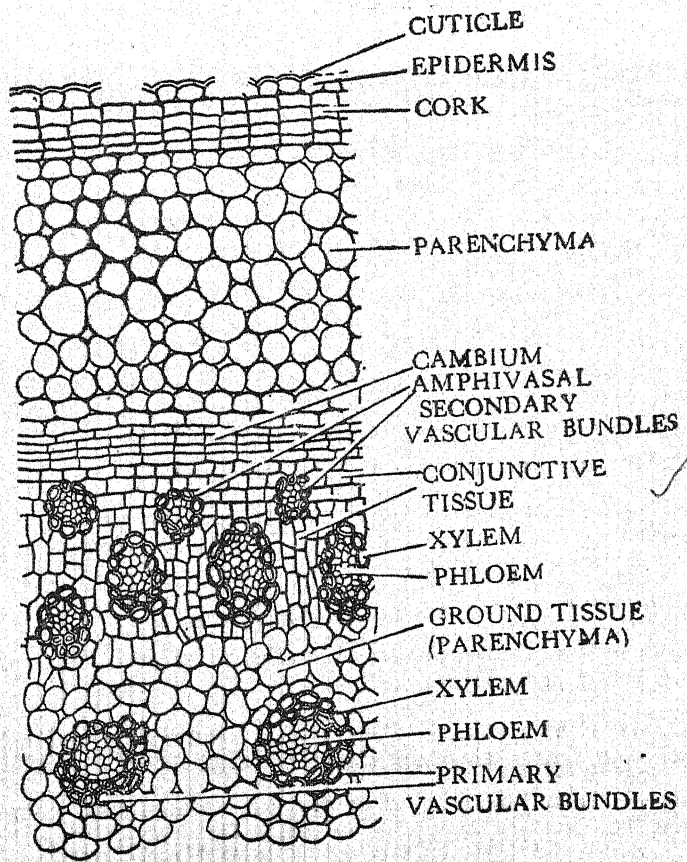


Fig. 64. A portion of the t.s. of stem of *Dracaena* showing abnormal secondary growth.

Identification

It is a monocot stem showing abnormal secondary growth because :

1. Cortex and pith are not differentiated. Ground tissue is present.

2. Primary vascular bundles, embedded in the parenchymatous ground tissue, are conjoint, collateral, numerous, scattered, closed and endarch. They may be amphivasal also.

3. Presence of cambium showing abnormal secondary growth.

4. Internal to the cambium secondary vascular bundles (amphivasal) are present embedded in the conjunctive tissue.

5. Presence of *storied cork* internal to the epidermis.

AERIAL ROOT OF FICUS BENGHALENSIS (Moraceae)

(1) In a t. s. the outline of the root is circular.

(2) The outer region is composed of thick-walled suberised rectangular cells knowo as *cork*. *Lenticels* may also be seen.

(3) Internal to cork is the *cork cambium* composed of thin-walled rectangular cells.

(4) Internal to it is the *cortex*. The Outer cortex is composed of thin-walled parenchymatous cells containing chloroplasts. These cells are called the chlorenchyma. The inner cortex is parenchymatous. *Stone cells* are seen distributed externally in the outer cortex.

(5) Primary vascular bundles are radial, xylem and phloem groups are alternate.

(6) In the early stage the cambium is present in the form of a wavy ring internal to the phloem and external to the exarch primary xylem groups. The cambium ring, at a later stage, becomes circular.

(7) Endodermis and pericycle are not well marked.

(8) Internal to cortex is *secondary phloem* (primary phloem is crushed). It consists of sieve tubes, companion cells, phloem parenchyma and phloem fibres. This portion of the root is soft

(9) *Cambium* is present internal to the phloem.

(10) Internal to cambium is the *secondary xylem* consisting of vessels, tracheids and xylem parenchyma.

(11) Opposite the primary xylem groups thin-walled parenchymatous elongated cells are seen. These are *medullary rays*.

(12) In the centre there is a large pith (like stems) composed of parenchyma cells.

(13) Tanin cells are seen throughout the section as black cells.

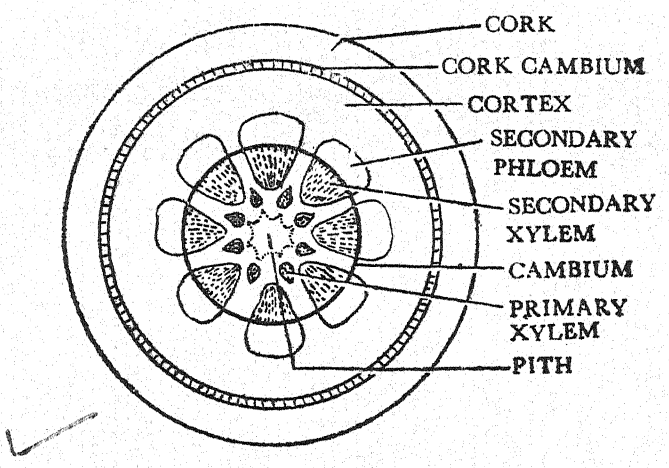


Fig. 65. Diagrammatic sketch of t. s. of the root of *Ficus benghalensis*.

Identification

It is a dicot root because ;

1. Primary xylem is exarch.
2. Xylem and phloem are radial and in alternate groups. Number is limited.
3. Presence of cambium and secondary tissues.

It is an aerial root because of the following characters ;

1. Presence of chlorenchyma in the cortex.
2. Presence of lenticels, cork and cork cambium.
3. Presence of large pith, large stele and small cortex.
4. Presence of stone cells shows its prop nature.

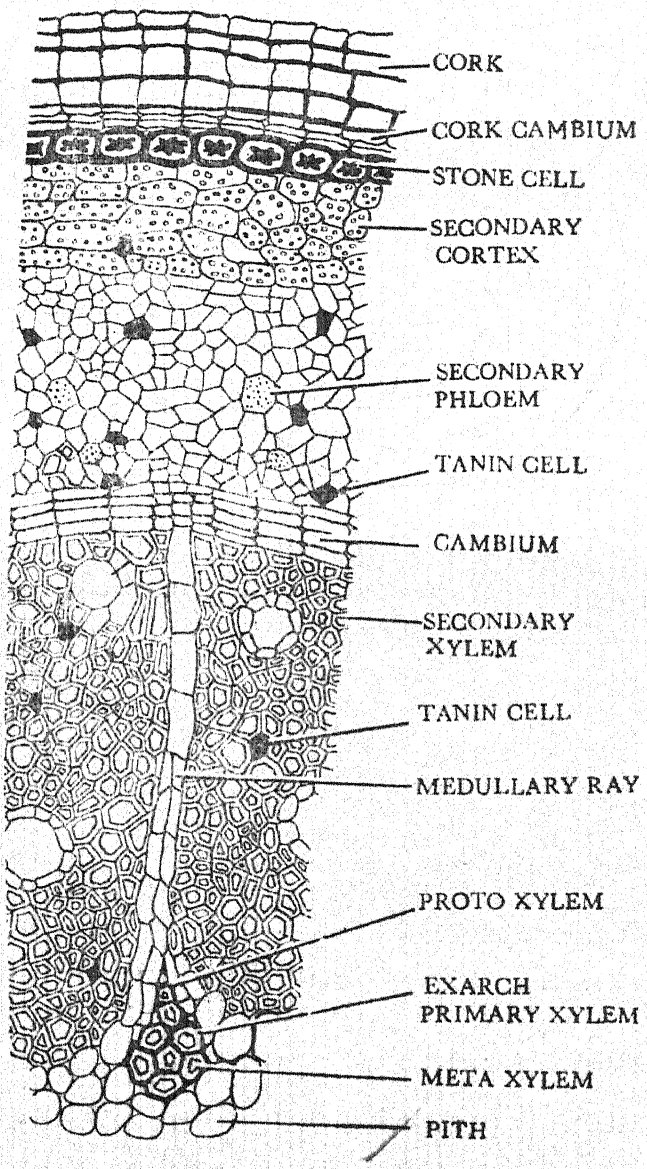


Fig. 66. A portion of the aerial dico root of *Ficuts benghalensis* under high power of the microscope.

AERIAL ROOT OF TINOSPORA (Menispermaceae)

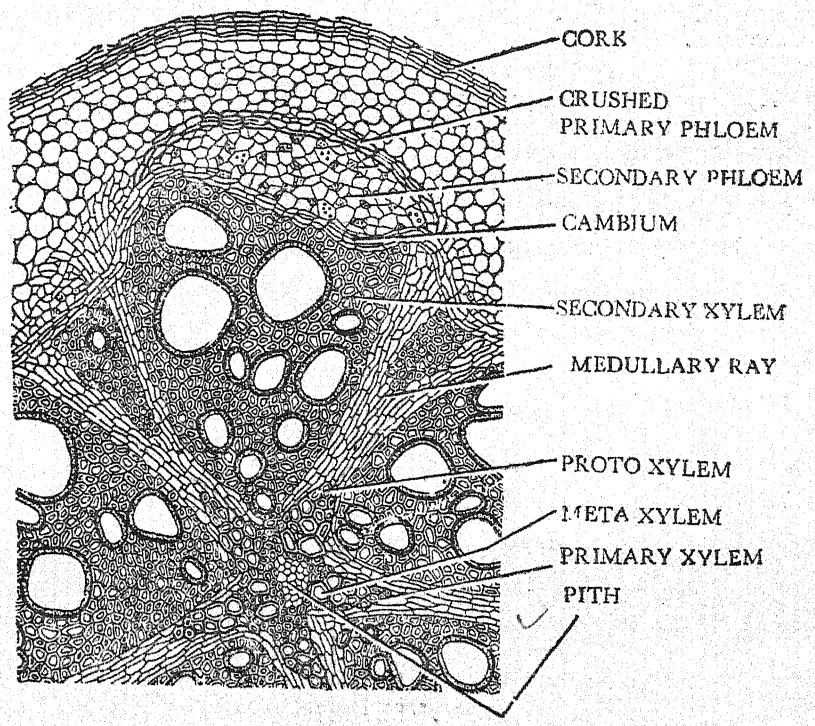


Fig. 67. A portion of the aerial dicot root of *Tinospora* under high power of the microscope.

(1) In a t. s. the root is almost circular in outline.

(2) Outermost region is the *cork* (lenticels may also be seen) below which cork cambium is present.

(3) Cortex is parenchymatous but the outer region consists of chlorophyllose cells.

(4) Secondary tissues are present in the stelar region.

(5) Primary vascular bundles are radial and xylem and phloem groups are separate and alternate.

(6) Primary xylem is exarch and tetrach. The metaxylem are larger and the protoxylem are smaller.

(7) Primary phloem are crushed and are seen as 4 convex arches alternating the primary xylem bundles.

(8) Cambium ring is present internal to the primary phloem and external to primary xylem. The ring is wavy but becomes circular at a later stage.

(9) Secondary phloem is present internal to the primary phloem and external to the cambium. It is composed of sieve tubes, companion cells and phloem parenchyma.

(10) Secondary xylem is formed internal to the cambium alternating with the primary xylem. It contains wide-mouth vessels, tracheids and xylem parenchyma. *Tyloses* are also seen in some of the vessels as baloon-like structures.

(11) A large parenchymatous pith is present in the centre.

Identification

It is a dicot root because :

1. Primary xylem exarch and tetrach.
2. Xylem and phloem radial, separate and alternate.
3. Cambium and secondary xylem and secondary phloem are present.

It is an aerial root because :

1. Chlorophyllose cells are present in the outer portion of the cortex.
2. Cork, cork cambium and lenticels are present.
3. Small cortex, large stele and large pith present.

MONOCOT ROOT OF VANDA (Orchidaceae)

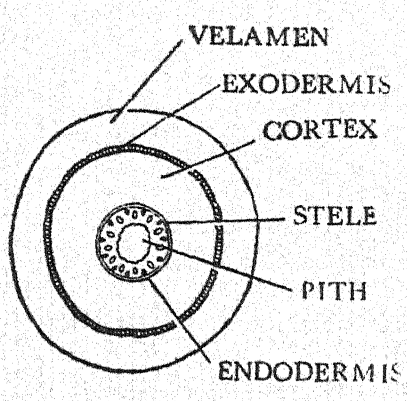


Fig. 68. Diagrammatic sketch of t. s. of root of an orchid showing velamen.

(1) The outline of the root in a t. s. is almost circular.

(2) The outermost region is the *velamen*. The cells of the velamen are thin-walled, radially elongated dead cells. These cells can absorb water from the humid atmosphere. It is multilayered. Some of the cells show spiral thickenings.

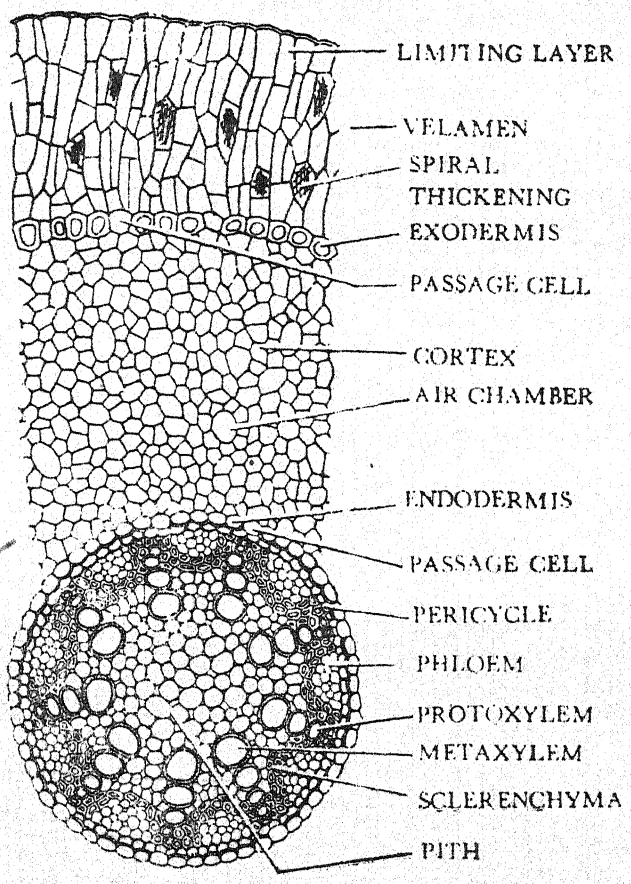


Fig. 69. A portion of the t. s. of an orchid root under the microscope.

(3) Internal to the velamen is a layer composed of lignified thick-walled radially elongated cells, the *exodermis.* The exodermis also contains thin-walled parenchymatous cells known as *passage cells.*

(4) Internal to exodermis is the multilayered broad zone of the cortex composed of thin-walled parenchymatous cells containing chlorophyll pigments.

(5) The innermost layer of the cortex is the *endodermis.* The cells are barrel-shaped and the radial walls are suberised. *Passage cells* also occur in the endodermis, usually opposite the protoxylem vessels.

(6) Pericycle is composed of thick-walled cells but thin-walled cells are also present opposite passage cells.

(7) A number of radial, separate and alterate groups of xylem and phloem are present in the stele.

(8) The xylem is exarch.

(9) Sclerenchymatous conjunctive tissue surround the phloem groups.

(10) The central pith is composed of parenchymatous cells but at a later stage these cells may show *sclerosis.*

(11) Secretary canals may also be seen in the pith.

Identification

It is a monocot root because :

1. Primary xylem is exarch.
2. Vascular bundles are radial, xylem and phloem are separate and alterate.
3. Number of vascular bundles more than six.
4. Small stele and large cortex.
5. Cambium and secondary tissues are absent.

It is aerial root because :

1. Velamen layer is present.
2. Exodermis (with passage cells) is present.
3. Chlorophyllose cells are present in the cortex.
4. Pith is large.

STORAGE ROOTS

BETA VULGARIS (Chenopodiaceae)

(1) The root of *Beta vulgaris* is swollen due to the accumulation of food.

(2) The outermost region is the periderm.

(3) Internal to it a number of growth layers are found.

(4) One growth layer consists of a ring of vascular bundles (secondary) and one ring of storage parenchyma (multilayered).

(5) In the centre exarch and diarch primary xylem is seen. The primary phloem is not seen as it is damaged due to the formation of the secondary vascular and storage tissues.

(6) Several cambial layers are formed in succession which form secondary tissues.

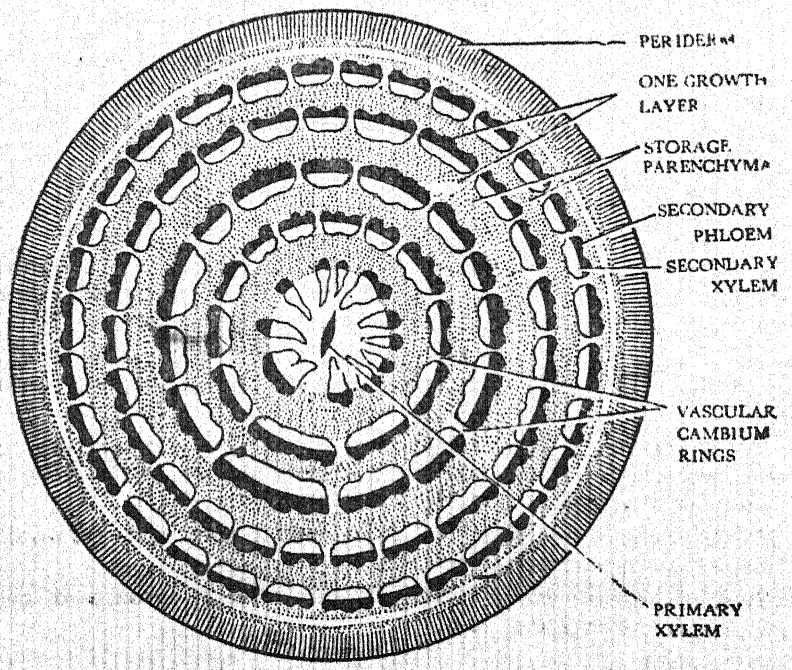


Fig. 70. Diagrammatic sketch of t.s. of the storage root of *Beta vulgaris* showing abnormal secondary growth.

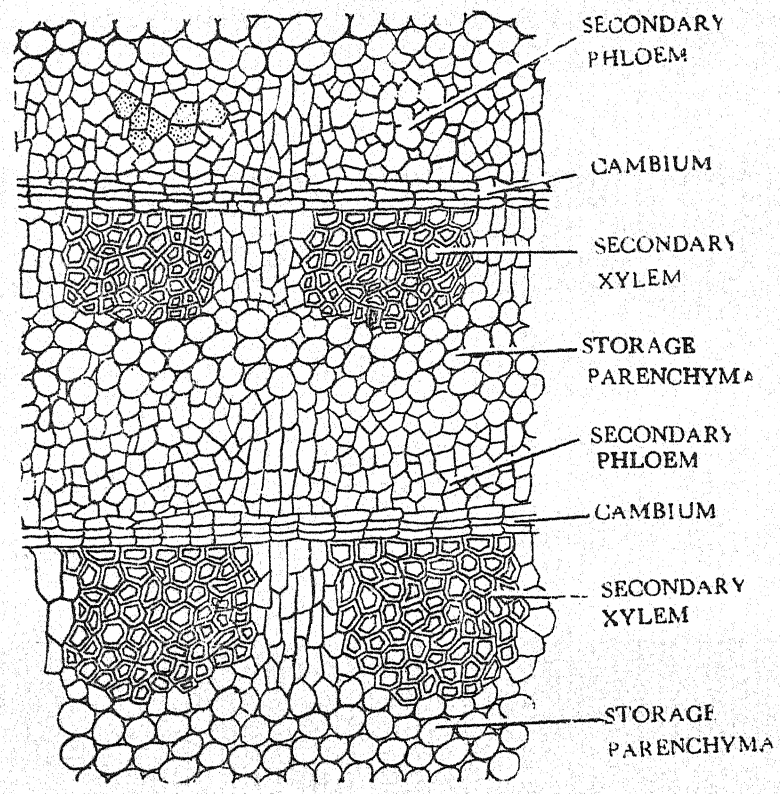


Fig. 71. A portion of the t. s. of root of *Beta vulgaris* showing cambium, secondary phloem, secondary xylem and storage parenchyma.

(7) Primary cambium arises from the parenchyma cells internal to phloem groups and external to xylem groups. This is joined by the cambium formed by pericycle opposite protoxylem groups. This is the first ring of cambium and it forms vascular bundles (phloem externally and xylem internally) separated by storage tissue composed of radially elongated thin-walled parenchyma.

(8) The vascular bundles are collateral, open and arranged in a ring.

(9) After some time the activity of the cambium ring ceases and a second ring (also called the first ring of secondary cambium) of cambium is formed from the phloem parenchyma outside the primary cambium and is also active like the previous cambium.

(10) A third ring of cambium is formed from the pericycle cells. It also forms the collateral vascular bundles and the storage parenchyma. Successive cambial rings are formed by the proliferation of the pericycle cells and produce alternating layers of vascular bundles and proliferated pericycle. The cells of proliferated pericycle store food.

(11) The root (and also the hypocotyl) increases in girth by the activity of the concentric layers of cambium and also by the proliferation of the pericycle.

Identification

It is a storage root because :

1. Primary xylem is exarch and diarch.
2. Concentric rings of vascular bundles alterating storage parenchyma are seen.
3. The vascular bundles are collateral and open and are separated by storage parenchyma.
4. *Periderm* is the outermost region of the root.

IPOMOEA BATATAS (Convolvulaceae)

Examine and sketch the permanent slide of the t. s. of the storage root of sweet potato (*Ipomoea batatas*). Comment upon its piculiar features and identify giving reasons.

(1) The primary xylem is exarch and pentarch or hexarch.
(2) The outermost region is the periderm.
(3) The cortex is wide, parenchymatous. It has intercellular spaces.
(4) In the early stage, the secondary growth is normal but at a later stage due to anomalous secondary growth, separate strands of secondary phloem and secondary xylem are formed in the ground tissue.

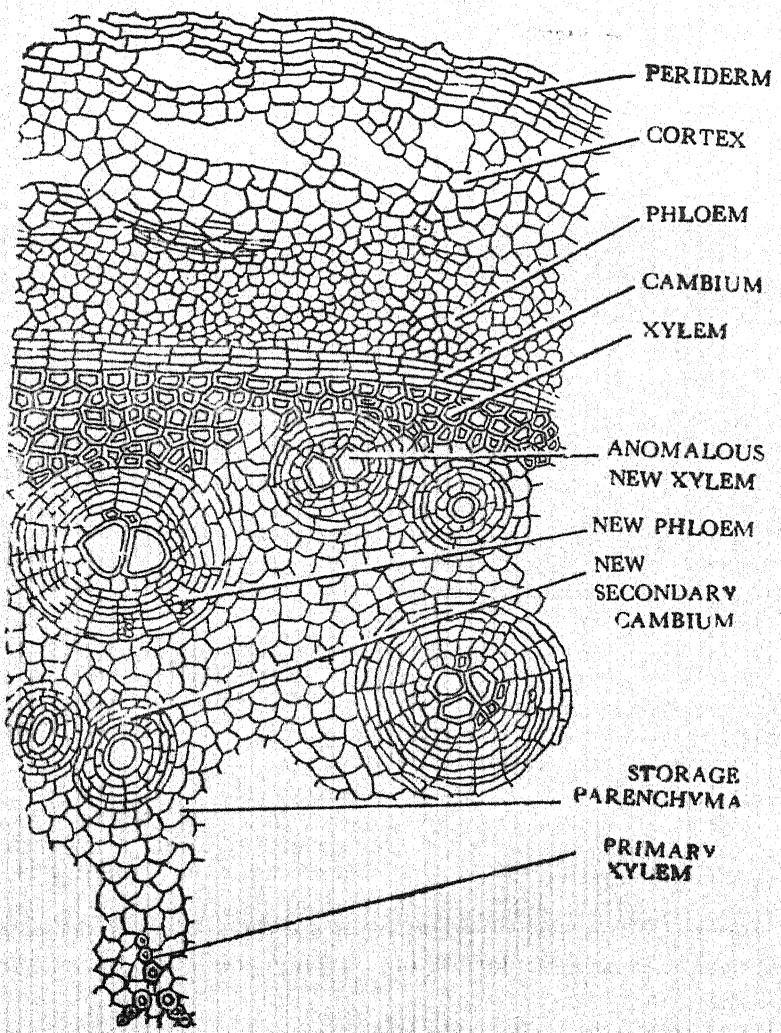


Fig. 72. A portion of the t. s. of the storage root of *Ipomoea batatas* showing anomalous secondary growth.

(5) Secondary cambium arises in the form of rings from the parenchyma cells of the ground tissue. These secondary cambial rings surround the xylem vessels or groups of vessels.

(6) These cambium rings are abnormal in activity. They form secondary xylem towards the centre and secondary phloem consisting of sieve tubes away from the centre. Laticiferous cells are also formed away from the centre. Large amounts of storage parenchyma are formed in both directions i.e. inside and outside the cambium ring.

(7) The huge amount of storage parenchyma makes the root to become tuberous.

(8) Tyloses may be seen in the larger vessels.

(9) The periderm originates from the pericycle in the peripheral region.

(10) The cortex is secondary in origin.

RAPHANUS SATIVUS (Cruciferae)

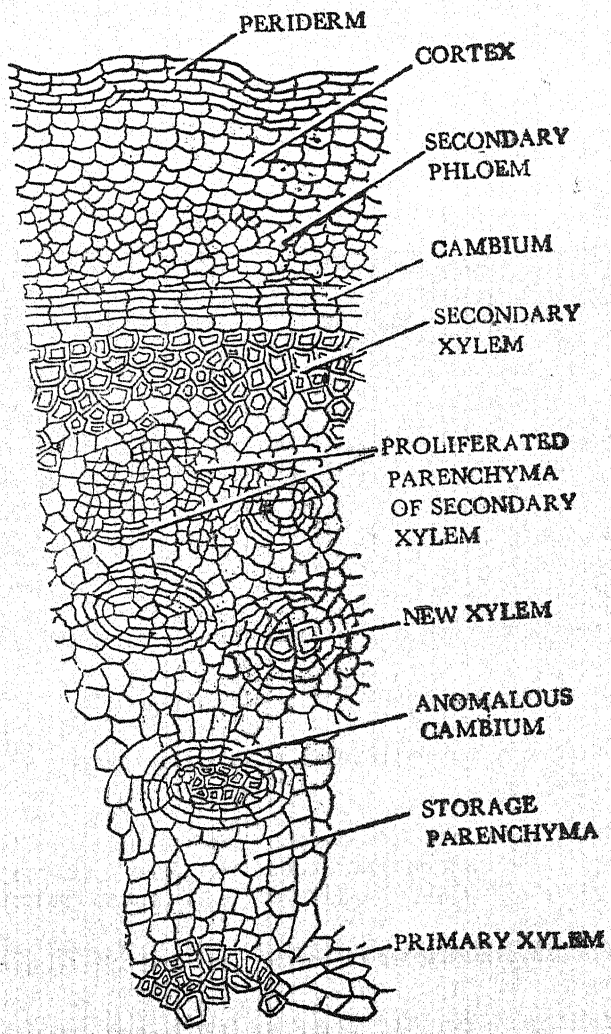


Fig. 73. A portion of the t. s. of the storage root of *Raphanus sativus*

(1) The primary xylem is exarch and diarch.

(2) In the early stage, the secondary growth is normal and the cambium cuts off secondary xylem internally and secondary phloem externally.

(3) The secondary xylem is peculiar in the sense that it contains a great amount of xylem parenchyma.

(4) The cells of the xylem parenchyma, here and there, become meristematic, divide and form rings of secondary cambium surrounding the groups of secondary xylem strands.

(5) The activity of the secondary cambium is abnormal. A few vascular elements are formed internally and storage parenchyma is formed both internally and externally.

(6) The primary cambium ring is pushed towards the periphery due to formation of secondary tissues and storage parenchyma.

(7) Periderm is seen in the extreme periphery of the root.

BREATHING ROOT

Examine and sketch the permanent slide of t. s. of a breathing root (pneumatophore) under the microscope and note its characteristic features.

(1) Cork and lenticels are seen in the extreme peripheral region. Lenticels help in the absorption of oxygen.

(2) Cortex is parenchymatous and shows air chambers.

(3) Endodermis is composed of barrel-shaped cells.

(4) The stele is large and contains a large central pith composed of parenchyma cells.

(5) The vascular bundles resemble the vascular bundles of dicotyledonous stems. They are conjoint, collateral, open, endarch and arranged in a ring. They form complete cylinders of xylem and phloem.

(6) Pericycle is composed of parenchyma and sclerenchyma both.

(7) The lenticels help the plant to breath and the air chambers help the plant to float.

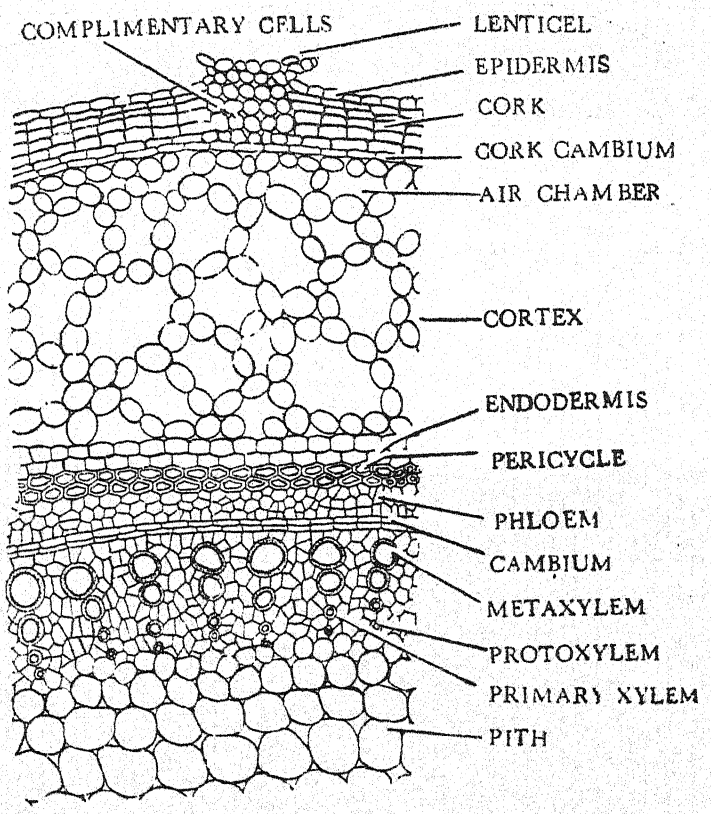


Fig. 74. A portion of the t. s. of a breathing root showing lenticel, air chambers, and stem-like vascular bundles.

ROOT OF A WATER PLANT

ROOT OF EICHHORNIA (Pontederiaceae)

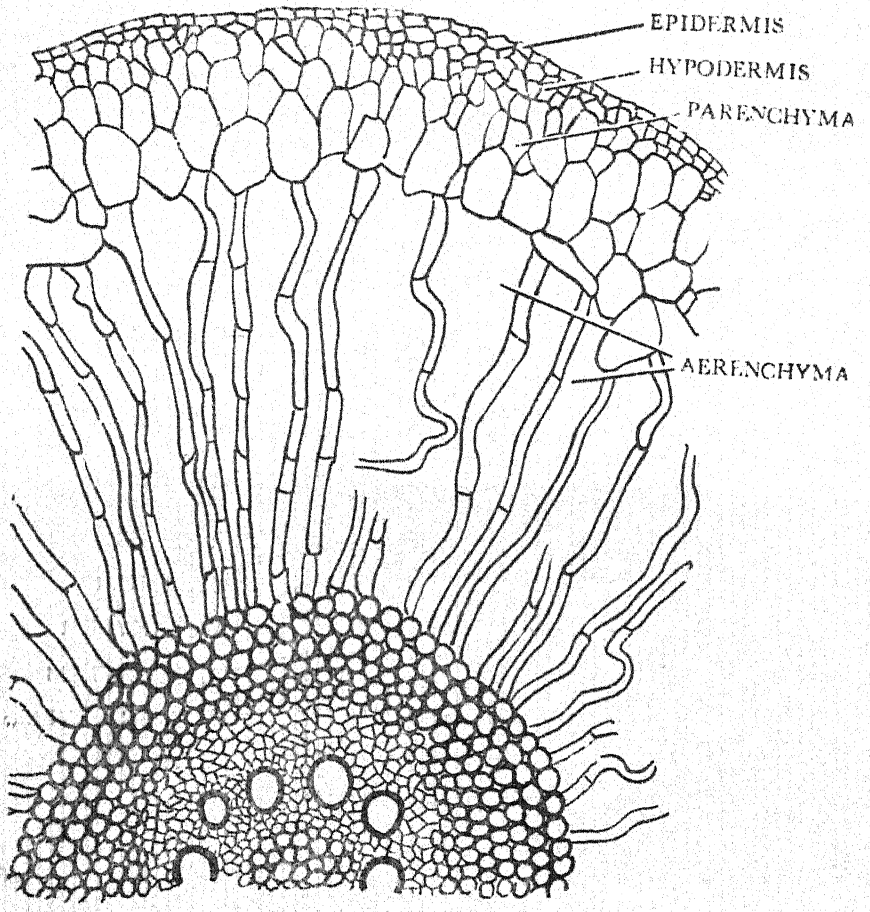


Fig. 75. A portion of the root of *Eichhornia* showing hydrophytic characters.

It is a hydrophytic root because :

(1) Epidermis lacks stomata. There is no cuticle.

(2) Cortex broad, parenchymatous with large air chambers.

(3) Ill developed vascular tissues.

(4) The cortex is large and the stele and the pith small.

(5) Primary xylem exarch.

LEAF

DORSIVENTRAL LEAF OF BANYAN

Prepare a double stained glycerine mount of the t. s. of banyan leaf. Examine and sketch under low and high powers of the microscope. Identify giving reasons.

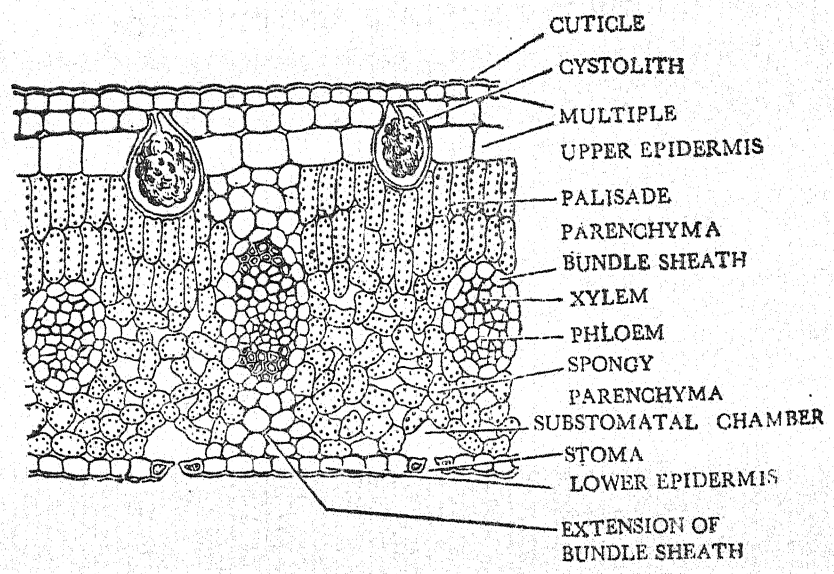


Fig. 76. A portion of the t. s. of leaf of *Ficus benghalensis* (Moraceae) showing multiple epidermis, *cystolith* and palisade and spongy parenchyma.

(1) The upper epidermis is multilayered (multiseriate) or multiple. Here and there, calcium carbonate crystals deposited on peg-like structures are seen. These are called *cystoliths*. Thick cuticle is present.

(2) The lower epidermis is uniseriate. Thick cuticle and stomata are present.

(8) In between upper and lower epidermis mesophyll (photosynthetic tissue) is present. It is differentiated into palisade and spongy parenchyma.

(4) The palisade parenchyma cells are thinwalled elongated cells and are compact. They are present internal to the upper epidermis and contain chloroplasts.

(5) The cells of the spongy parenchyma are thin-walled, isodiametric, irregular, with intercellular spaces, contain chloroplasts and are found internal to the lower epidermis.

(6) The vascular bundles are collateral, closed, xylem on upper and phloem on lower side, and are surrounded by parenchymatous bundle sheath. Bundle-sheath extentions are associated with larger vascular bundles. The arrangement of the bundles is parallel.

(7) Sub-stomatal chambers are seen opposite stomata.

Xerophytic Characters

1. Presence of thick cuticle on both upper and lower epidermis.
2. Stomata restricted only to the lower surface.
3. Presence of cystolith and multiple upper epidermis.

FICUS ELASTICA LEAF WITH CYSTOLITH

(1) The leaf is a dorsiventral leaf.

(2) The upper epidermis is multiseriate or multiple. There is a thick cuticle.

(3) Some of the epidermal cells are abnormally large and they contain crystals of calcium carbonate aggregated (deposited) on peg-like projections of the wall. The depositions look like bunches of grapes. Such structures are called *cystoliths*.

(4) In between upper and lower epidermis is the mesophyll which is differentiated into palisade parenchyma (internal to the upper epidermis) and spongy parenchyma (internal to the uniseriate lower epidermis). The mesophyll cells contain chloroplasts.

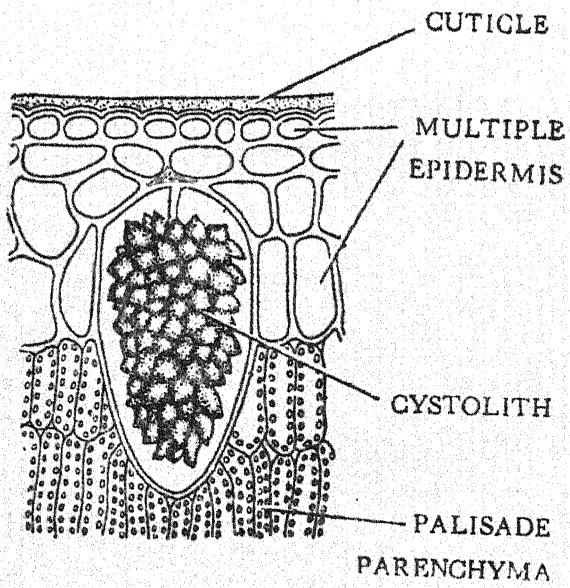


Fig. 77. A portion of the t. s. of leaf of India rubber (*Ficus elastica*) of Moraceae showing multiple upper epidermis, *cystolith* and palisade parenchyma.

Xerophytic Characters

1. Thick cuticle present on both the surfaces of the leaf.
2. Presence of multiple epidermis.
3. Presence of cystolith.
4. Stomata restricted to the lower epidermis only.

DORSIVENTRAL LEAF OF NERIUM

(1) The leaf of oleander (*Nerium*) of the family Apocynaceae is a dorsiventral xerophytic leaf.

(2) The upper epidermis is multiseriate (multiple) and the outermost layer shows thick cuticle on the outer walls.

(3) Stomata are restricted to the lower epidermis. They are sunken (present in the stomatal pits) and are guarded by hairs (epidermal out growths).

(4) Mesophyll is differentiated into palisade and spongy parenchyma. It is present in between upper and lower epidermis.

(5) Internal to the upper epidermis three or more layers of palisade parenchyma is present. The cells contain chloroplasts, are compact with very little intercellular spaces.

(6) Internal to the lower epidermis palisade parenchyma is single layered.

(7) Spongy parenchyma is present in between the upper and the lower palisade parenchyma. The cells show intercellular spaces. They contain chloroplasts.

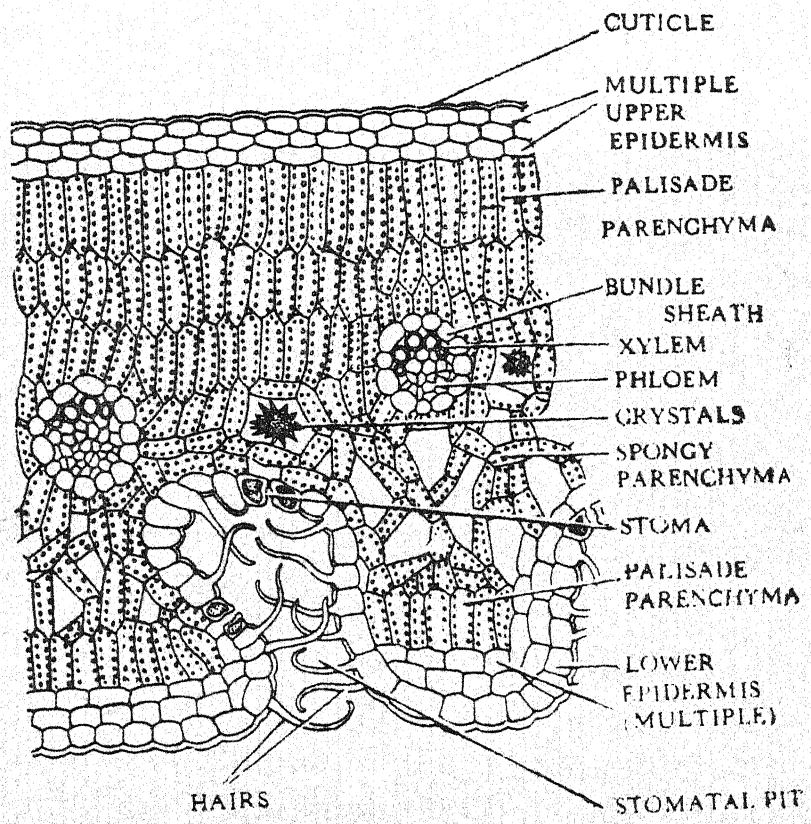


Fig. 78. A portion of the t. s. of a xerophytic leaf of *Nerium* showing multiple epidermis, crystals of calcium oxalate and sunken stomata present in the stomatal pit.

(8) Crystals of calcium oxalate are present here and there.

Xerophytic Characters

1. Presence of thick cuticle.
2. Presence of multiple epidermis.
3. Stoma restricted to the lower epidermis.
4. Stomata present in the stomatal pits and are also guarded by hairs so as to check water loss.
5. Presence of crystals of calcium oxalate.

GRASS LEAF SHOWING HINGE CELLS

(1) This is a t. s. of the leaf of the grass *Psamma*.

(2) During the times of water deficiency the surface which bears stomata becomes the inner surface because the leaves roll up. The stomata are protected by wind action.

(3) The upper surface of the leaf consists of a number of ridges and grooves. The stomata occur on the base of the grooves on the sides.

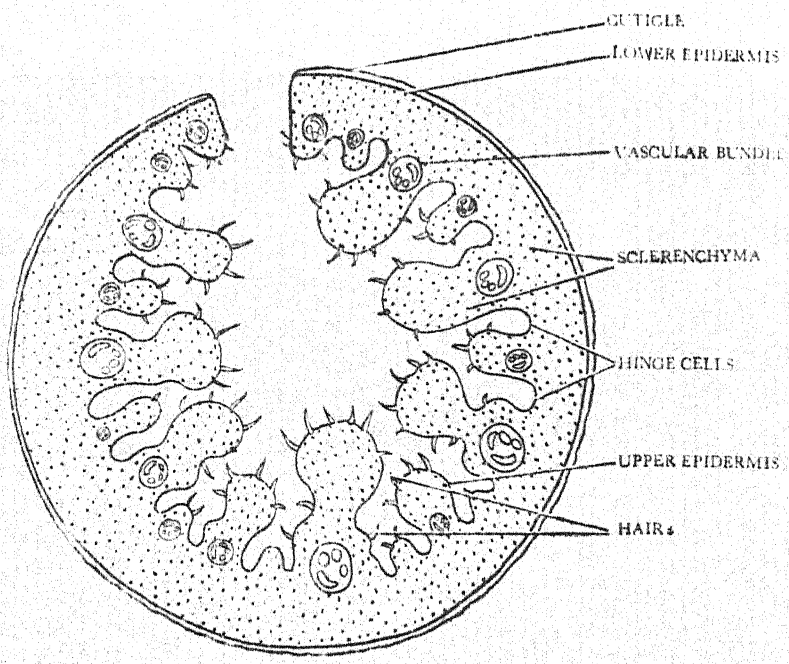


Fig. 79. Diagrammatic sketch of t. s. of the leaf of the grass *Psamma* of Gramineae.

(4) Large thin-walled cells are present at the base of the groves. These are called *hinge cells*. They lose water more rapidly. Thus at the time of water scarcity the leaf rolls up protecting the stomata and the lower epidermis becomes the outer surfare.

(5) At the sides of the hinge cells photosynthetic tissue (chlorenchyma) is present.

(6) The stomata are protected by hairs.

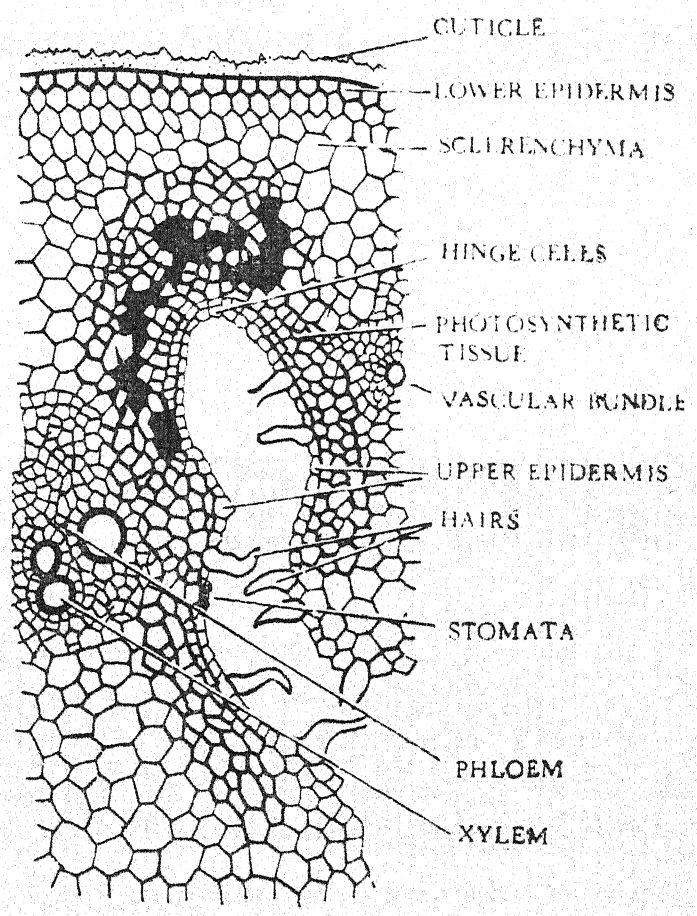


Fig. 80. A portion of the t. s. of the leaf of *Psamma* showing detailed structure.

(7) The leaf unrolls when moisture (water) is available.

HYDROPHYTIC LEAF OF NYMPHAEA

(1) This is a t. s. of the leaf of waterlily (*Nymphaea*) of Nymphaeaceae.

(2) Both the upper and the lower epidermis is uniseriate.

(3) Stomata are present on the upper epidermis and slime glands are present on the lower epidermis.

(4) Cuticle is present on the upper epidermis but there is no cuticle on the lower epidermis as the lower epidermis is in touch with water.

(5) Internal to the upper epidermis compact palisade parenchyma is present.

(6) Internal to the lower epidermis spongy parenchyma is present containing large air chambers.

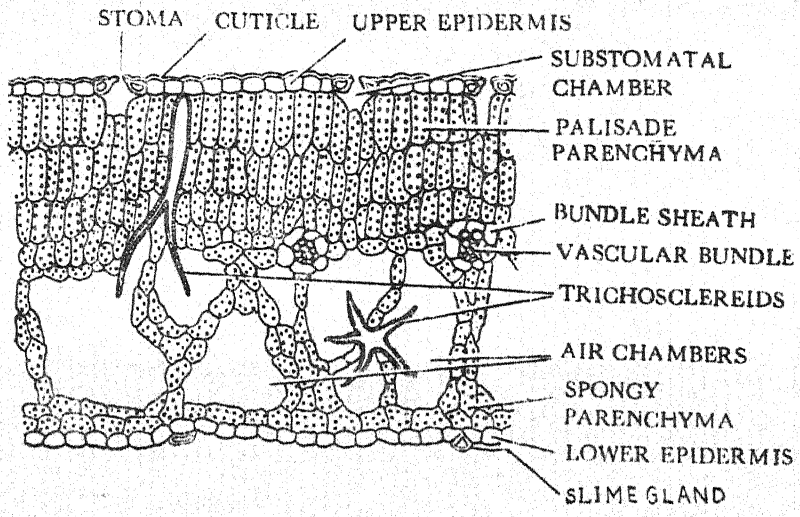


Fig. 81. A portion of the t. s. of floating leaf of *Nymphaea.*

(7) Trichosclereids are also present.

(8) Vascular bundles are highly reduced.

Hydrophytic Characters

(1) Absence of cuticle and stomata and presence of slime gland on the lower epidermis.

(2) Presence of air chambers.

(3) Presence of much reduced vascular bundles.

(4) Presence of trichosclereids (internal hairs).

PETIOLE OF NYMPHAEA

(1) This is circular in outline in a transverse section.

(2) Internal to epidermis is the collenchymatous hypodermis.

(3) Internal to hypodermis is parenchyma containing large air chambers.

(4) Vascular bundles show scanty xylem and phloem (vascular bundles are much reduced).

(5) Trichosclereids are also present.

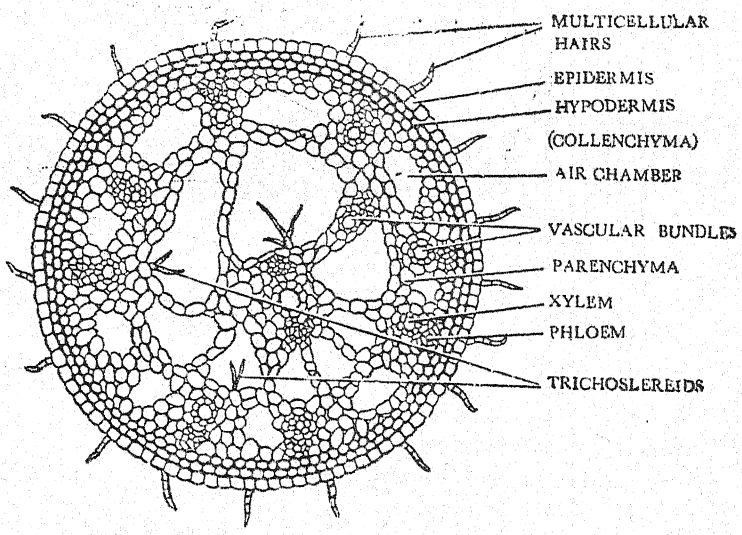


Fig. 82. T. S. of the leaf of *Nymphaea* showing air chambers, trichosclereids and reduced vascular bundles.

Hydrophytic Characters

(1) Absence of cuticle and stomata from the epidermis.
(2) Presence of large air chambers or lacunae.
(3) Poorly developed vascular bundles.
(4) Presence of sclerotic cells (trichosclereids).

WHEAT LEAF SHOWING BULLIFORM CELLS

(1) The upper epidermis contains large cells known as bulliform cells. Stomata are also present.

(2) The bulliform cells are water containing cells and are often filled with silica.

(3) Bulliform cells store water, help the young leaves to unroll or help in opening and closing movements of the mature leaves.

(4) The lower epidermis also contains stomata.

(5) Inbetween upper and lower epidermis mesophyll is present.

(6) Vascular bundles are also present.

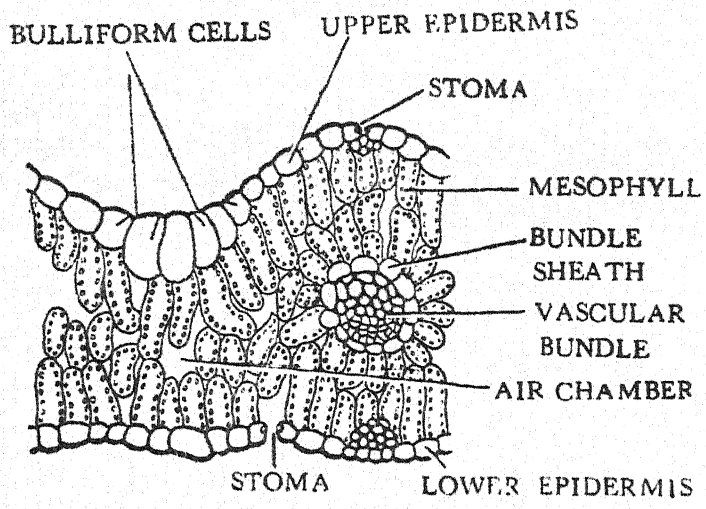


Fig. 83. A portion of the t. s. of leaf of wheat (*Triticum aestivum*) of Gramineae family showing bulliform cells.

Xerophytic Characters

(1) Presence of cuticle.

(2) Presence of bulliform cells.

LEAF OF BAMBUSA (BAMBOO)

(1) This is a t. s. of the leaf of *Bambusa* (Graminaceae) showing bulliform cells.

(2) Bulliform cells are present in the upper epidermis. The lower epidermis contains stomata. Silica is also deposited. Hairs are also present.

(3) In between upper and lower epidermis is mesophyll undifferentiated into palisade and spongy parenchyma. Here and there air chambers are also present.

(4) Vascular bundles are collateral and closed and are arranged in parallel series. They are surrounded by the bundle sheaths.

(5) Patches of sclerenchyma are present on the upper and the lower sides of the vascular bundles.

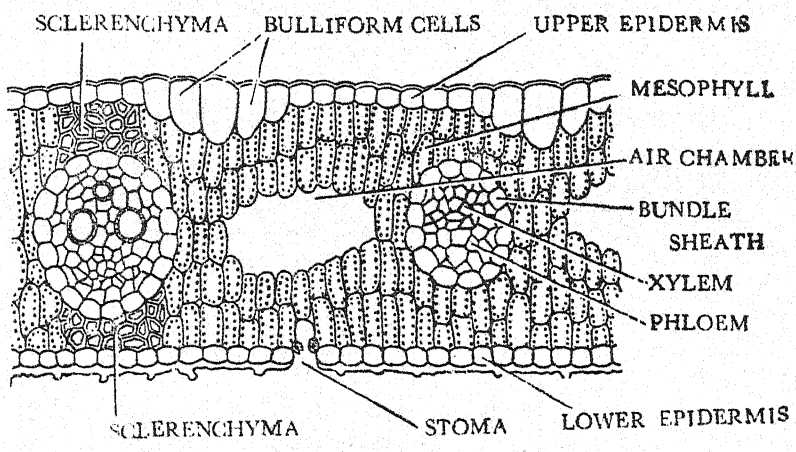


Fig. 84. A portion of the t. s. of the leaf of *Bambusa* showing bulliform cells.

Xerophytic Characters

1. Presence of cuticle and silica in epidermis.
2. Stoma present on the lower surface only.
3. Presence of bulliform cells.
4. Presence of stiff and sharply pointed hairs on the lower epidermis.

PHYLLODE OF ACACIA

(1) This is a t. s. of phyllode of *Acacia* (Mimosaceae).

(2) Phyllode is a modification of petiole. The petiole becomes flattened and leaf-like.

(3) It is isobilateral. The middle portion is swollen on both sides.

(4) Sunken stamata are present in the upper and the lower epidermis. Cuticle is also present.

(5) Internal to the upper and the lower epidermis, in lateral portions, mesophyll is present. It is differentiated into palisade and spongy parenchyma (pith).

(6) In the middle portion, patches of sclerenchyma surround the two large vascular bundles.

(7) The vascular bundles posses well developed xylem and phloem and are arranged in a ring.

(8) Smaller vascular bundles are present in the lateral portions of petiole and have patches of sclerenchyma on the upper sides.

(9) Each vascular bundle is conjoint, collateral and closed.

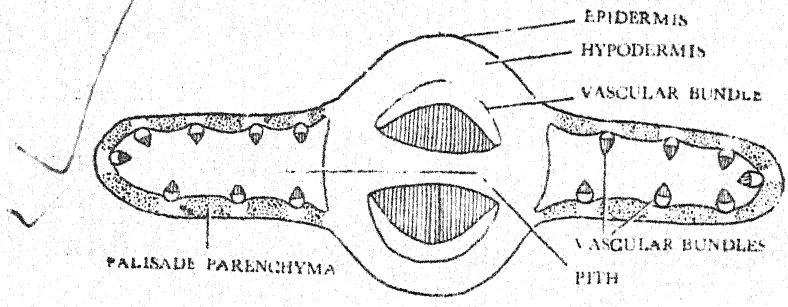


Fig. 85. Diagrammatic sketch of the t. s. of phyllode of *Acacia*.

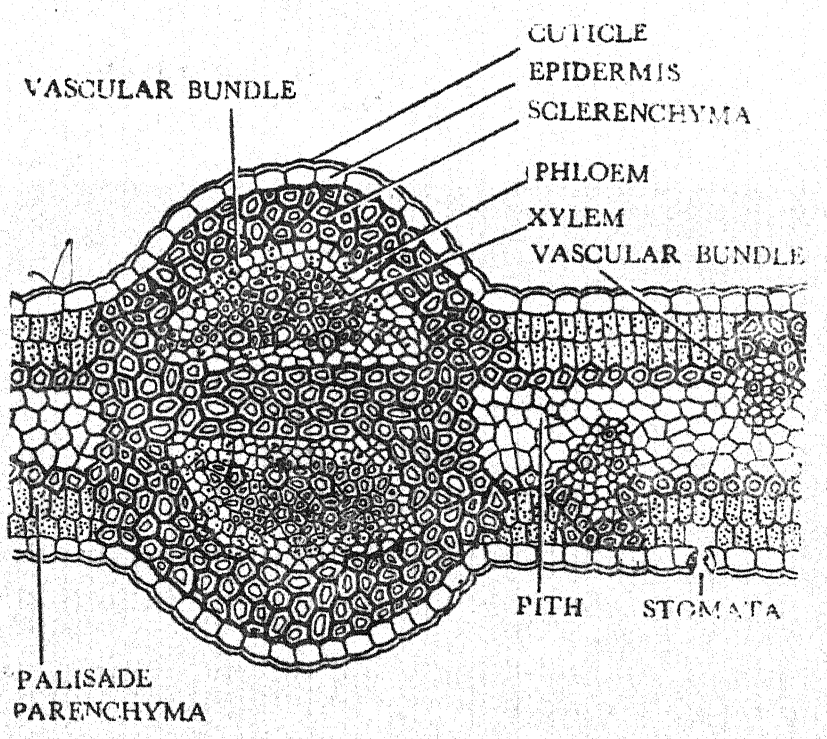


Fig. 86. A portion of the t. s. of phyllode of *Acacia* showing cellular structure.

Xerophytic Characters

1. Presence of cuticle and sunken stomata.
2. Presence of sclerenchyma.
3. Presence of well developed vascular tissues

4. Absence of air chambers.
5. Prensece of palisade parenchyma.

PHYLLOCLADE OF MUEHLENBECKIA

(1) In a transverse section the outline appears as dorsiventrally flattened.

(2) Epidermis is single layered with sunken stomata and thick cuticle.

(3) Internal to epidermis, cortex or palisade parenchyma is present except above the vascular bundles.

(4) Internal to the vascular bundles parenchymatous pith is present.

(*a*) The vascular bundles are arranged in a ring.

(6) Each vascular bundle is conjoint, collateral, open and endarch.

(7) Endodermis is not well marked.

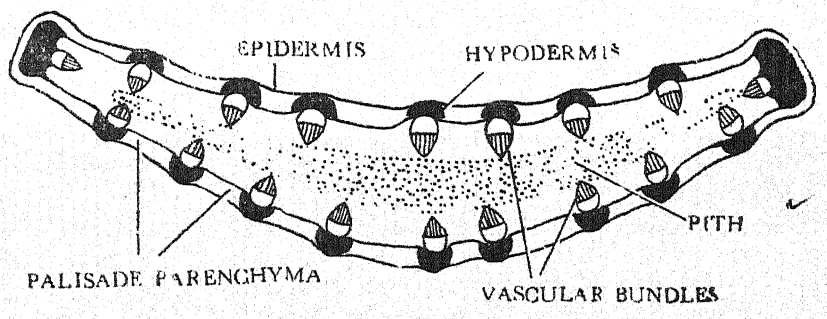


Fig. 87. Diagrammatic sketch of the t. s. of phylloclade of *Muehlenbeckia.*

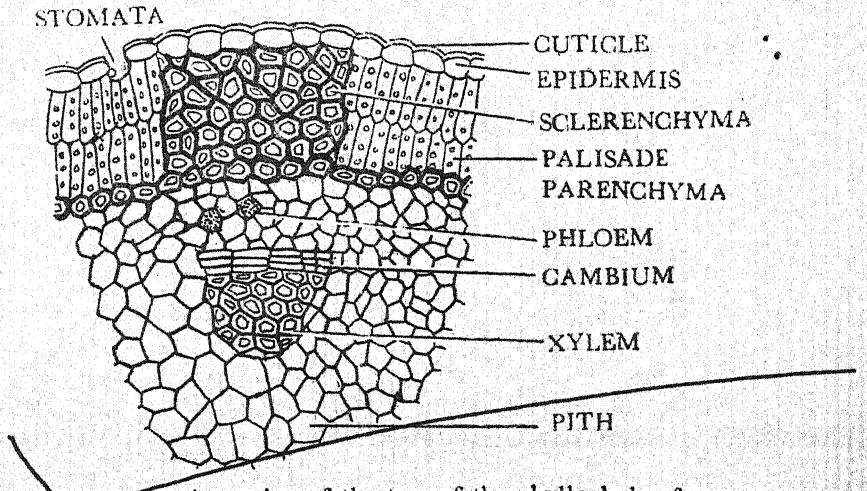


Fig. 88. A portion of the t. s. of the phylloclade of *Muehlenbeckia* under the microscope.

It is a dicot stem because :

1. Cortex and pith differentiated.
2. Vascular bundles are arranged in a ring.
3. Each vascular bundle is conjoint, collateral, open and endarch.

At the same time it also shows the following leaf characters :

1. It is dorsiventrally flattened leaf-like green structure.
2. Presence of palisade parenchyma.

Therefore this material is a *phylloclade*.

ANOMALOUS STRUCTURS

DICOT STEM OF BIGNONIA OR PYROSTEGIA (Bignoniaceae)

Prepare a double stained glycerine mount of the t. s. of the stem of *Bignonia*. Examine and sketch under low and high powers of the microscope. Note its peculiar features and identify giving reasons.

(1) In a t. s. the outline of the stem is wavy (roughly quadrangular).

(2) It is differentiated into epidermis, cortex and stele.

(3) Epidermis is the outermost layer. There is a thickening of cuticle on the outer walls of the epidermal cells.

(4) Internal to epidermis is hypodermis composed of collenchymatous cells. It is 2-3 layered In older stems cork is present.

(5) Internal to it there is an outer cortex of chlorenchymatous cells and inner cortex of parenchymatous cells. Patches of sclerenchyma are present at the four corners.

(6) Endodermis is not well marked.

(7) Internal to endodermis is multilayered pericycle composed of irregular patches of sclerenchyma and also parenchyma.

(8) Stele is polyfascicular siphonostele or *eustele* showing secondary xylem and secondary phloem.

(9) In the centre there is parenchymatous pith.

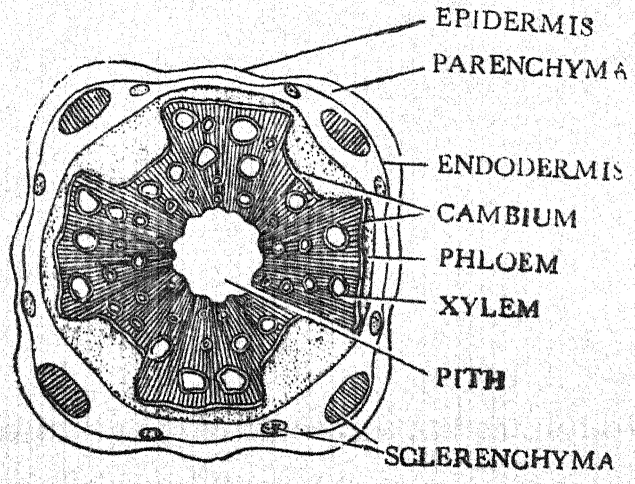


Fig. 89. Diagrammatic sketch of the stem of *Bignonia* as seen in a t. s.

(10) In the begining of the secondary growth the fascicular cambium joins the interfascicular cambium and normal cambium ring is formed.

(11) This cambium ring is normal in its activity as it forms secondary phloem externally and secondary xylem internally.

(12) At places the activity is abnormal as the upper layer of cambium is more active and forms secondary phloem in increased amounts. Usually there are four such places. As a result wedge shaped areas of secondary phloem apper in the secondary xylem. Grooves become increasingly deeper with secondary growth.

(13) The cambium becomes wavy in outline and ultimately gets broaken into strips.

(14) In the advanced stage of secondary growth horizontal bars or plates of secondary phloem fibres appear. These are lignified cells.

(15) Well developed secondary medullary rays are also seen.

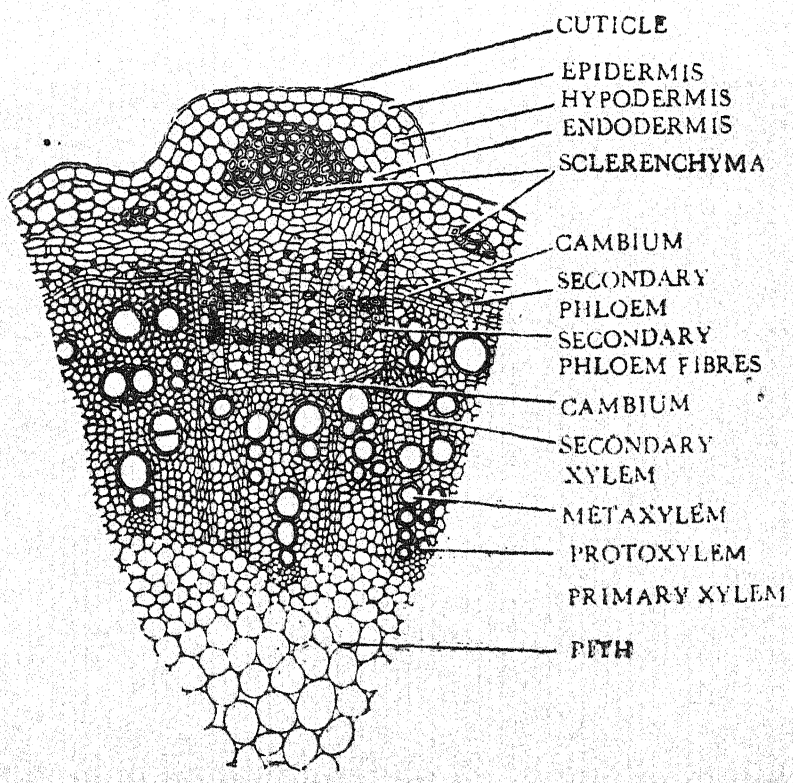


Fig. 90. A portion of the t. s. of the stem showing wedge-shaped area of secondary phloem in secondary xylem.

Identification

It is a dicot stem because :

1. Cortex small and large stele.
2. Primary vascular bundles are conjoint, collateral, open, endarch and arranged in a ring.
3. Presence of chlorenchyma in the cortex.
4. Presence of secondary xylem and secondary phloem.
5. Wedge-shaped areas of secondary phloem are seen.
6. Transverse bars or plates of fibres are seen in the grooves.

Abnormality

Presence of wedge-shaped areas at four corners formed due to abnormal activity of the upper layer of the cambium ring at these places.

DICOT STEM OF TECOMA (Bignoniaceae)

(1) In a t. s the outline of the stem is wavy.
(2) Epidermis shows cuticle on the outer walls.
(3) The cortex is parenchymatous. In young stems outer cortex is chlorenchymatous.
(4) Endodermis is not well marked.
(5) Pericycle shows patches of sclerenchyma embedded in parenchyma.
(6) Internal to pericycle is secondary phloem (primary phloem is crushed).
(7) There is a ring of cambium internal to the secondary phloem.
(8) Internal to the cambium ring is secondary xylem and then primary xylem.

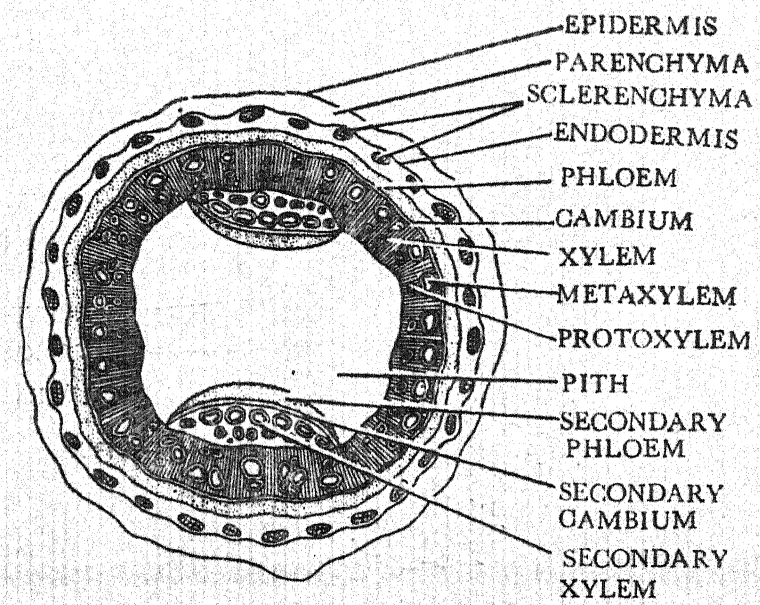


Fig. 91. Diagrammatic structure of the stem of *Tecoma* showing normal and abnormal secondary growths.

(9) In the peripheral region of the pith, internal to the primary xylem bundles, abnormally formed two or more patches of secondary tissues are seen.

(10) In the centre there is a large pith.

(11) The primary vascular bundles are conjoint, collateral, open, endarch and are arranged in a ring.

(12) The cambium ring is normal.

(13) It forms secondary xylem internally and secondary phloem externally in the normal manner.

(14) Internal to primary xylem, in the peripheral region of the parenchymatous pith, strips of meristematic tissue (2 or more) appear. This is called secondary cambium.

(15) The activity of this secondary cambium is abnormal as it cuts off secondary xylem externally and secondary phloem internally.

(16) As a result to this, the pith cells internal to these secondary tissues are crushed and are seen as dark lines.

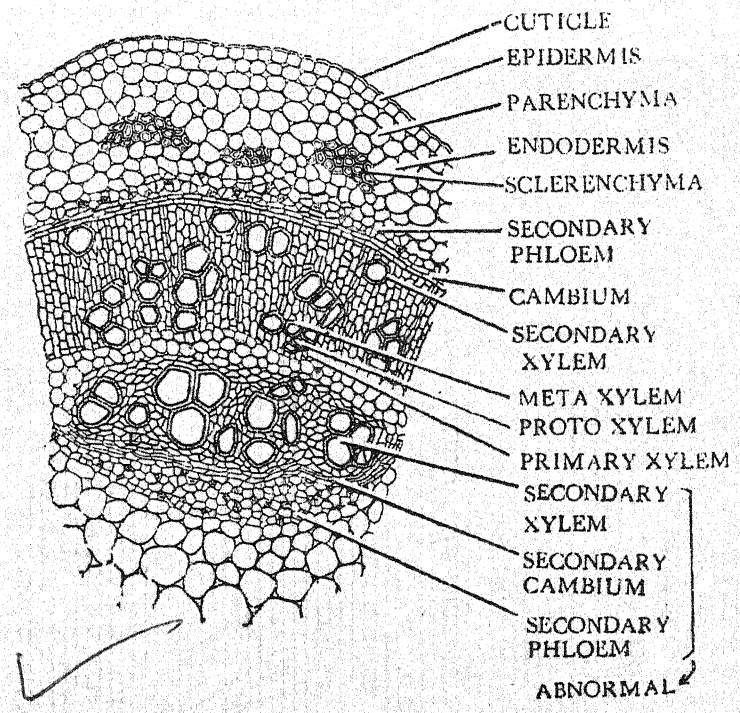


Fig. 92. A portion of the t. s. of stem of *Tecoma* showing normal and abnormal secondary growth.

Identification

It is a dicot stem because ;

1. Small cortex, large stele with large pith present.

2. Primary vascular bundles are conjoint, collateral, open, endarch and are arranged in a ring.
3. There is cuticle on the epidermis.
4. Secondary tissues are present.

Abnormality

1. Presence of secondary open vascular bundles in the peripheral region of the pith.
2. The orientation of xylem and phloem is not normal as secondary xylem is formed externally and secondary phloem internally.

DICOT STEM OF BOERHAAVIA (Nyctaginaceae)

(1) In a transverse section the outline is roughly circular.
(2) Multicellular hairs and cuticle is present on the epidermis. Stomata are also seen.
(3) Internal to epidermis is collenchymatous hypodermis.
(4) Cortex is parenchymatous. In young stems outer cortex is chlorenchymatous.
(5) Endodermis is single layered and is composed of thin-walled barrel-shaped cells.
(6) Pericycle is parenchymatous with isolated strands of sclerenchyma fibres or stone cells.
(7) Internal to pericycle primary vascular bundles are arranged in 3 rings. Two inner rings of primary vascular bundles being present in the pith.
(8) In the innermost ring, in the pith, there are two large vascular bundles. In the middle ring there are 6-14 smaller vascular bundles and in the outermost ring there are 15-20 or more minute vascular bundles.
(9) Each primary vascular bundle is conjoint, collateral open and endarch.

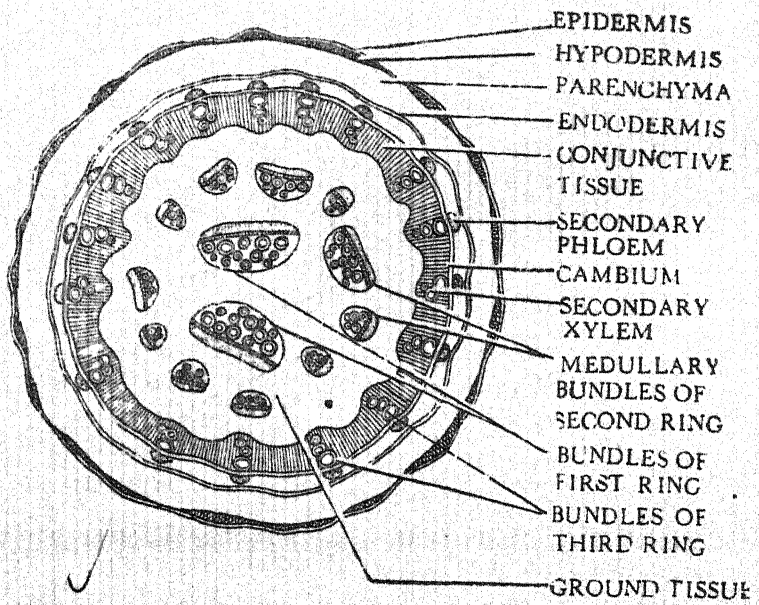


Fig. 93. Diagrammatic structure of the t. s. of stem of *Boerhaavia diffusa* showing abnormal secondary growth.

(10) In the inner two rings of the primary vascular bundles the secondary growth is limited to the vascular bundles and the secondary growth is normal. Interfascicular cambium is not formed.

(11) Abnormal secondary growth takes place in the region of the outermost ring of minute bundles where cambium ring is formed.

(12) In the fascicular region the secondary growth is normal. But in the interfascicular region the secondary growth is abnormal.

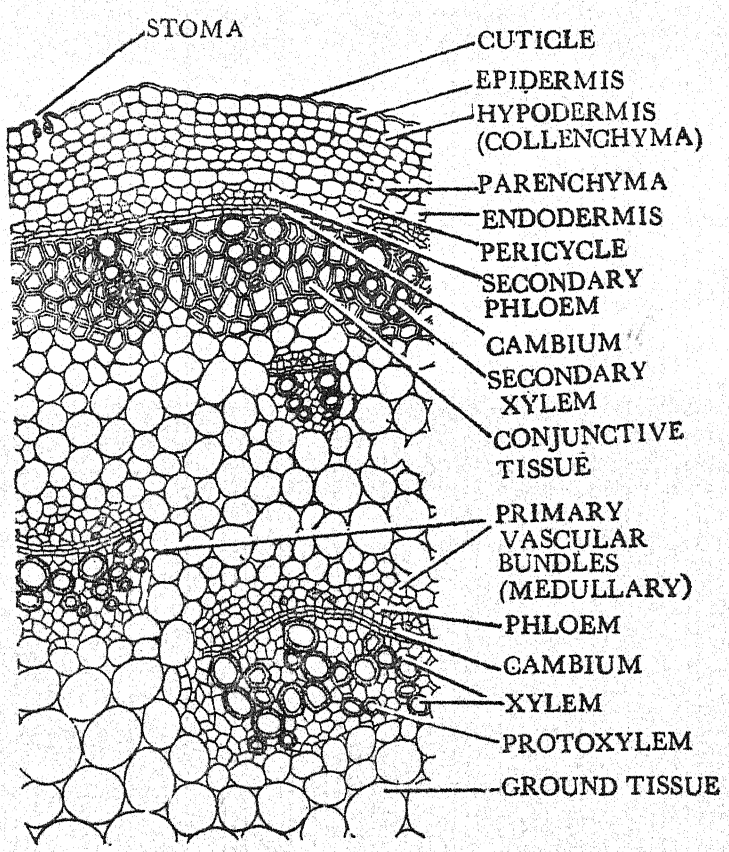


Fig. 94. A portion of the t. s. of stem of *Boerhaavia* showing anomalous secondary growth.

(13) The interfascicular cambium forms small patches of secondary xylem embedded in conjunctive tissue internally. Scanty phloem is formed externally opposite secondary xylem and also secondary parenchyma. The activity of this cambium declines soon.

(14) New secondary cambium is formed in the parenchyma outside the secondary phloem. This secondary combium again forms secondary xylem and conjunctive tissue internally and parenchyma and scanty phloem opposite xylem externally.

(15) In this manner other cambia may arise producing a few growth

rings out side the previous one. Thus the secondary vascular bundles are seen embedded in the conjunctive tissue.

(16) In the extreme periphery of the cortex, cork cambium is formed which forms cork and lenticels externally and secondary perenchyma internally.

(17) At an advanced stage of the secondary growth the cells of the conjunctive tissue become thick-walled, lignified and prosenchymatous.

Identification

1. Epidermis with cuticle, stomata and multicellular hairs.
2. Cortex is small, stele and pith large.
3. Lenticels are present in the cortex breaking the epidermal layer at several places.
4. Vascular bundles arranged in three rings (2 large bundles in inner, 6-14 in middle and 15-20 or more in outer).
5. Presence of medullary bundles.
6. Primary bundles are conjoint, collateral, open and endarch.
7. Limited secondary growth (to only bundles) in the inner and middle rings of vascular bundles.
8. Presence of growth rings. Secondary vascular bundles embedded in thick walled prosenchymatous conjunctive tissue. This is due to abnormal secondary growth.

IV. STEM OF BOUGAINVILLEA (Nyctaginaceae)

(1) Thick cuticle is present on the epidermis.
(2) Cork and cork cambium present.
(3) Cortex is parenchymatous. Collenchyma is also seen.
(4) Endodermis is not well marked after secondary growth.
(5) Pericycle shows isolated strands of fibres or stone cells.
(6) Primary vascular bundles are scattered in the pith region. These are called medullary bundles.
(7) There is a ring of smaller primary vascular bundles.
(8) Each primary vascular bundle is collateral, open and endarch.

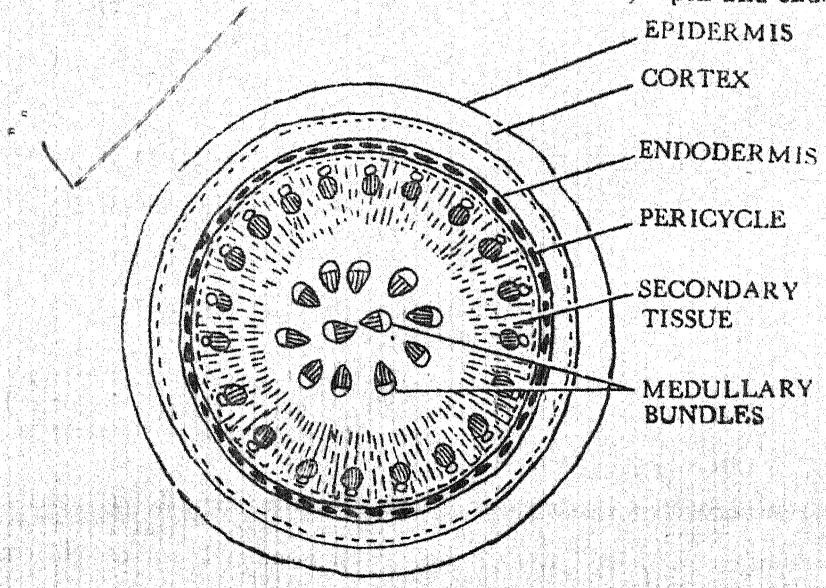


Fig. 95. Diagrammatic structure of the t.s. of the stem of *Bougainvillea* showing abnormal secondary growth.

(9) Secondary growth in the primary medullary bundles is limited only to the fascicular region as the bundles are scattered.

(10) Cambium ring is formed in the region of the outermost bundles which are present in a ring.

(11) In the interfascicular region secondary xylem and conjunctive tissue are formed internally and secondary phloem and secondary parenchyma externally.

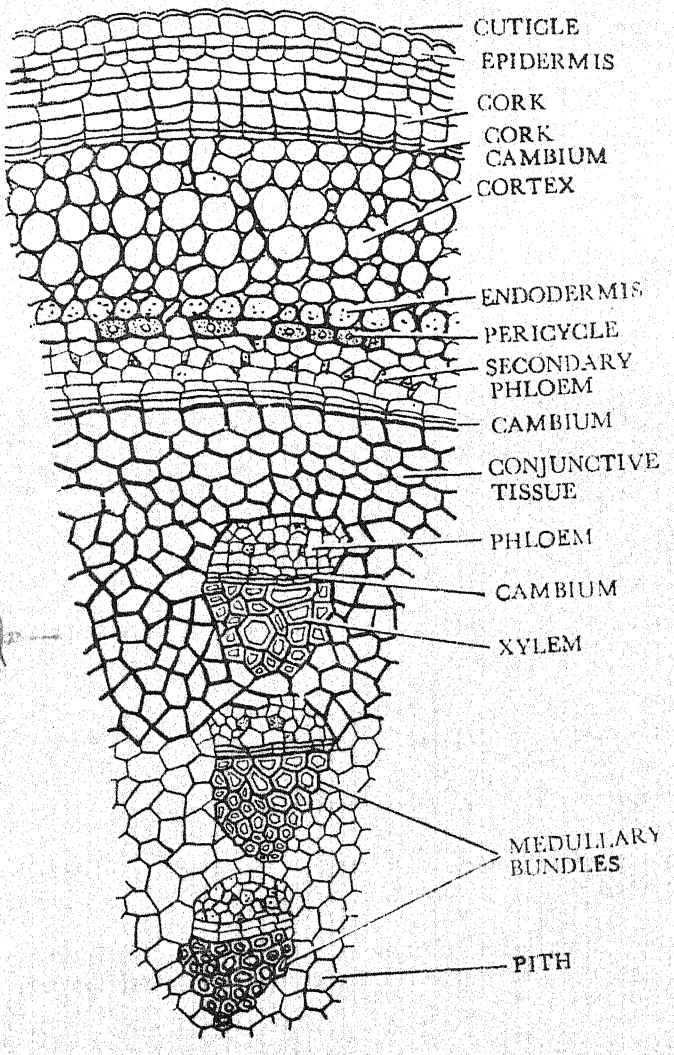


Fig. 96. A portion of t.s. of the stem of *Bougainvillea* showing primary medullary vascular bundles and abnormal secondary growth.

(12) Due to excessive secondary growth the vascular bundles are seen

embedded in the conjunctive tissue and when the cells of the conjunctive tissue also become lignified, isolated strands of the secondary phloem look embedded in the conjunctive tissue but actually they are not strands of included phloem.

Identification

1. Epidermis shows thick cuticle.

2. Cortex small, large stele and large pith.

3. Primary vascular bundles collateral, open and endarch.

4. Presence of scattered primary medullary bundles.

5. Secondary growth limited to the bundles in the inner scattered medullary bundles.

6. Presence of secondary vascular bundles, embedded in the conjunctive tissue formed due to abnormal secondary growth.

7. Presence of cork cambium and cork in the peripheral region of the cortex internal to the epidermis.

STEM OF MIRABILIS (Nyctaginaceae)

(1) It is roughly quadrangular in outline in a t. s.

(2) Internally it resembles the stem of *Boerhaavia* but the vascular bundles are more numerous.

(3) The bundles in the central region are larger in size than the bundles in the peripheral region.

(4) Primary vascular bundles are collateral, open and endarch.

(5) In the primary medullary bundles the secondary growth is limited only to the bundles.

(6) The fascicular cambium of the primary vascular bundles (of peripheral region) join with the interfascicular cambium and a ring of cambium is formed.

(7) The activity of this cambium ring resembles with that of *Boerhaavia*.

(8) This cambium ring cuts off secondary xylem and conjunctive tissue internally (xylem being embedded in it) and secondary phloem and very little secondary parenchyma externally.

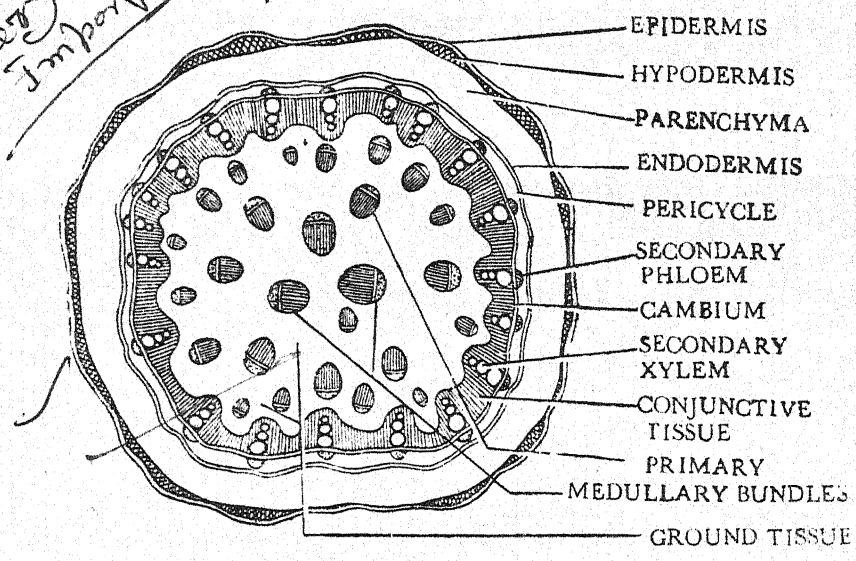


Fig. 97. Digrammatic structure of the t. s. of the stem of *Mirabilis jalapa* showing anomalous secondary growth.

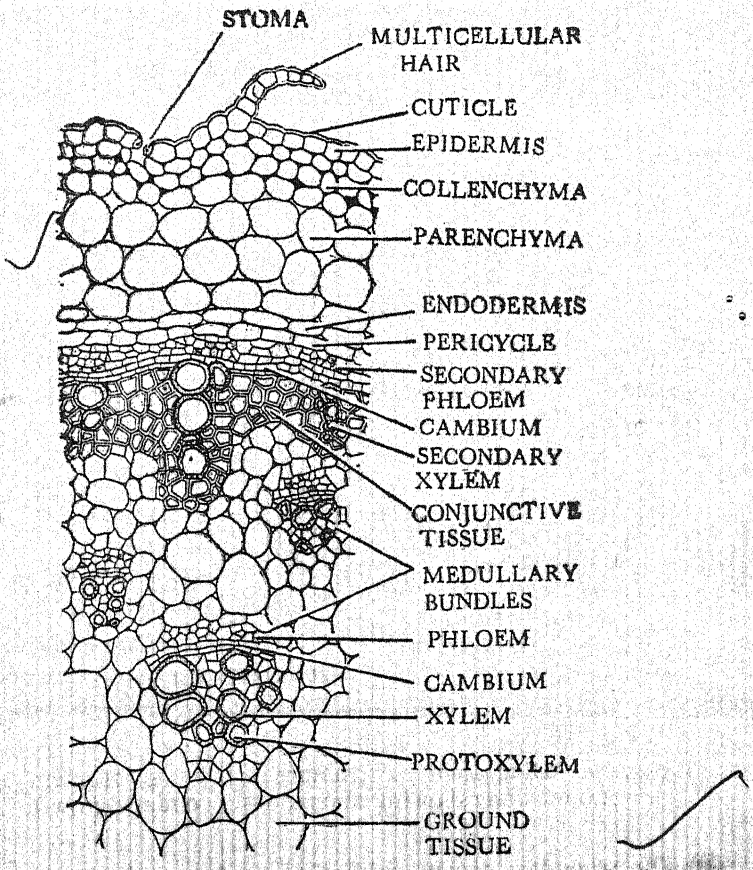


Fig. 98. A portion of the t. s. of the stem of *Mirabilis jalapa* showing anomalous secondary growth.

Identification

1. Presence of cuticle, stomata and multicellular hairs in epidermis.
2. Small cortex, large stele and large pith.
3. Presence of numerous primary medullary vascular bundles.
4. Primary vascular bundles collateral, open and endarch.
5. Hypodermis collenchymatous.

6. Secondary growth in the primary vascular bundles limited only to the bundles.

7. Formation of cambium ring in the peripheral vascular bundles.
8. Abnormal activity of the cambium ring as conjunctive tissue and secondary xylem (embedded in it) are formed internally and secondary phloem and secondary parenchyma externally.

STEM OF AMARANTHUS (Amaranthaceae)

(1) The outline of the stem in a t. s. is more or less circular.
(2) Epidermis is uniseriate with cuticle and stomata.
(3) Hypodermis is collenchymatous and it is interrupted by chlorenchyma.

(4) Endodermis is wavy in outiine.
(5) Internal to the endodermis is parenchymatous pericycle.

(6) The primary vascular bundles are collateral, open, endarch and scattered in the medulla or pith.

(7) Pith is large and parenchymatous.

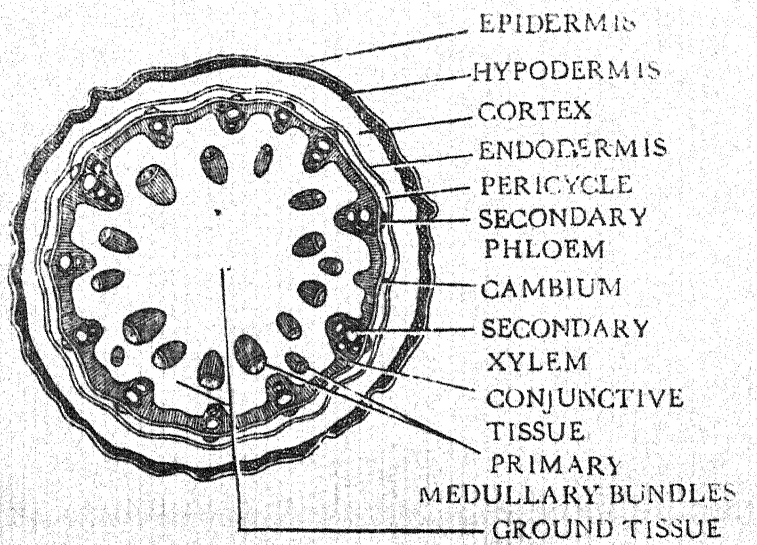


Fig. 99. Diagrammatic structure of the t. s. of stem of *Amaranthus* showing anomalous secondary growth.

(8) The secondary growth is limited only to the fascicular region in the primary vascular bundles.

(9) Outside the primary vascular bundles a new meristem or a ring of secondary cambium originates in the pericycle (in *Achyranthes* secondary cambium is in the form of separate strips or arcs of mesistem).

(10) Internal to the secondary cambium conjunctive tissue and secondary xylem are formed, secondary xylem being embedded in thin-walled parenchymatous conjunctive tissue. Externally secondary phloem is formed opposite secondary xylem.

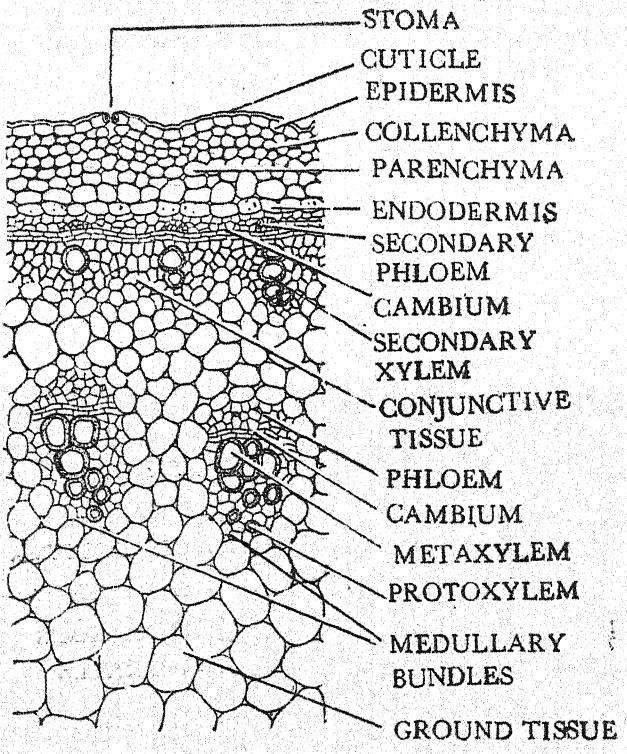


Fig. 100. A portion of the t. s. of stem of *Amaranthus* showing anomalous secondary growth.

Identification (Achyranthes dicot stem).

(1) Cortex small, stele and pith large.
(2) Vascular bundles collateral, open and endarch.
(3) Chlorenchyma present in cortex.
(4) Secondary tissues are present.
(5) Endodermis and pericycle present.
(6) Epidermis with cuticle and stomata. & hairs

Abnormality

(1) Vascular bundles numerous in number.
(2) Vascular bundles scattered in the pith.

(3) Secondary growth limited to the bundles only. Cambium ring is not formed by usual fascicular and interfascicular cambium.

(4) A ring of secondary cambium originates in the pericycle region.

(5) Secondary cambium is abnormal in activity. Internally it forms secondary xylem embedded in parenchymatous conjunctive tissue and externally secondary phloem opposite secondary xylem.

STEM OF CHENOPODIUM (Chenopodiacee)

(1) The outline of the stem in a t. s. is more or less circular.

(2) Outermost layer is epidermis. There is cuticle on the outer walls.

(3) Hypodermis is collenchymatous and multilayered.

(4) Cortex is parenchymatous. These cells may contain chloroplasts in young stems.

(5) Endodermis is single layered.

(6) Internal to endodermis is parenchymatous pericycle.

(7) Internal to the pericycle are a large number of primary vascular bundles in a concentric ring.

(8) Each bundle is collateral, open, endarch.

(9) The primary vascular bundles (medullary) grow in thickness to some extent by secondary growth which is limited to the vascular bundles.

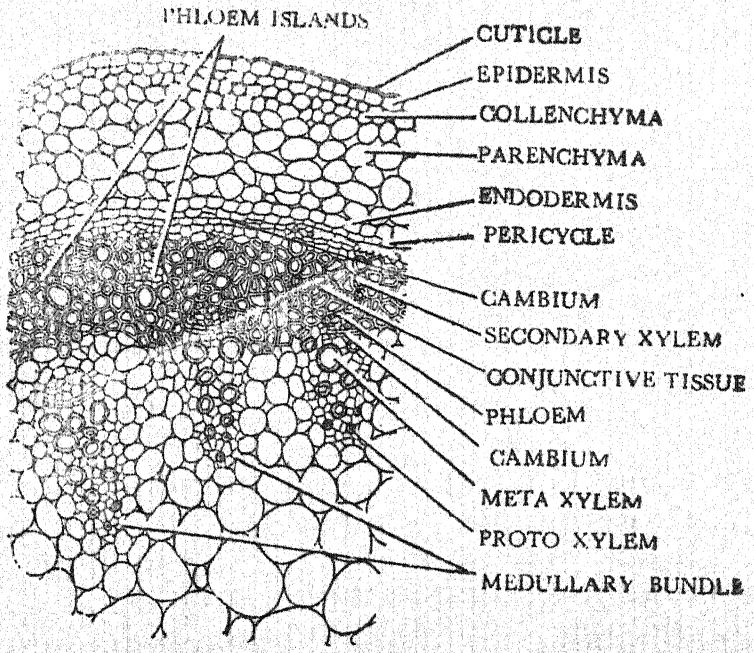


Fig. 101. A portion of the t. s. of the stem of *Chenopodium* showing abnormal secondary growth.

(10) Arcs of secondary cambium originate in the pericycle or phloem. Thus these cambial arcs are extrastelar in origin.

(11) Secondary cambial arc forms conjunctive tissue in which the bundles remain embedded. The cells of the conjunctive tissue are lignified thick-walled cells.

(12) Secondary vascular bundles are collateral (phloem outside and xylem inside).

(13) Concentric zones of secondary vascular bundles arise from successive cambial arcs (rings).

(14) Isolated strands of secondary phloem are found embedded in the secondary xylem. The fact is that secondary phloem is formed centrifugally (external to cambium) and then new arc arises on the phloem which cuts off tissues in the same manner. Thus phloem patch is completely surrounded by xylem.

(15) After the secondary growth has taken place, the primary vascular bundles are pushed towards pith or centre.

Identification

1. Differentiation into epidermis, cortex and stele.
2. Endodermis and pericycle present.
3. Hypodermis collenchymatous.
4. Cortex small, stele and pith large.
5. Primary medullary vascular bundles collateral, open, endarch and in a concentric ring.
6. Secondary vascular bundles are collateral and embedded in the lignified conjunctive tissue. They are in concentric rings.
7. Isolated patches of secondary phloem are also seen in the conjunctive tissue surrounded by secondary xylem.

Abnormality

1. Presence of medullary bundles.
2. Limited secondary growth in primary bundles.
3. Origin of successive arcs or rings of secondary cambium in pericycle and phloem.
4. Collateral secondary vascular bundles embedded in conjunctive tissue in concentric rings
5. Patches of secondary phloem surrounded by secondary xylem.

STEM OF NYCTANTHES (Oleaceae)

(1) In a t. s. the outline of the stem is squarish with four prominent ridges at the four corners.

(2) Epidermis is cuticularised. Stomata and multicellular hairs are also present.

(3) Hypodermis is collenchymatous.

(4) Outer cortex is chlorenchymatous and inner cortex is parenchymatous.

(5) Four *cortical vascular bundles* are present below the ridges in the cortical region. These are inversely oriented. Xylem outside, phloem inside and cambium in between xylem and phloem.

(6) Endodermis is single layered and not well marked.

(7) Pericycle is internal to the endodermis and is parenchymatous. It is interrupted by sclerenchyma patches.

(8) Stele shows secondary growth (secondary xylem and secondary phloem).

(9) The primary vascular bundles, in the stelar region, are conjoint, collateral, open endarch and are arranged in a ring.

(10) After secondary growth primary phloem and endodermis are not well marked.

(11) Pith is large and parenchymatous.

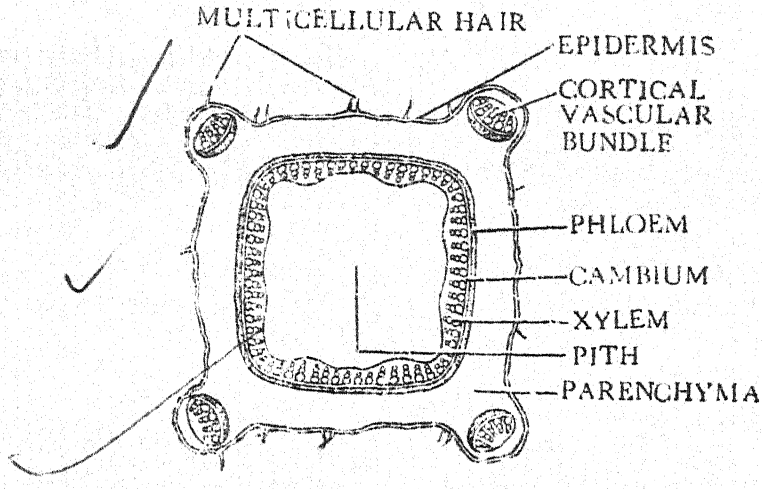


Fig. 102. Diagrammatic structure of the t. s. of the stem of *Nyctanthes* showing cortical bundles and secondary growth.

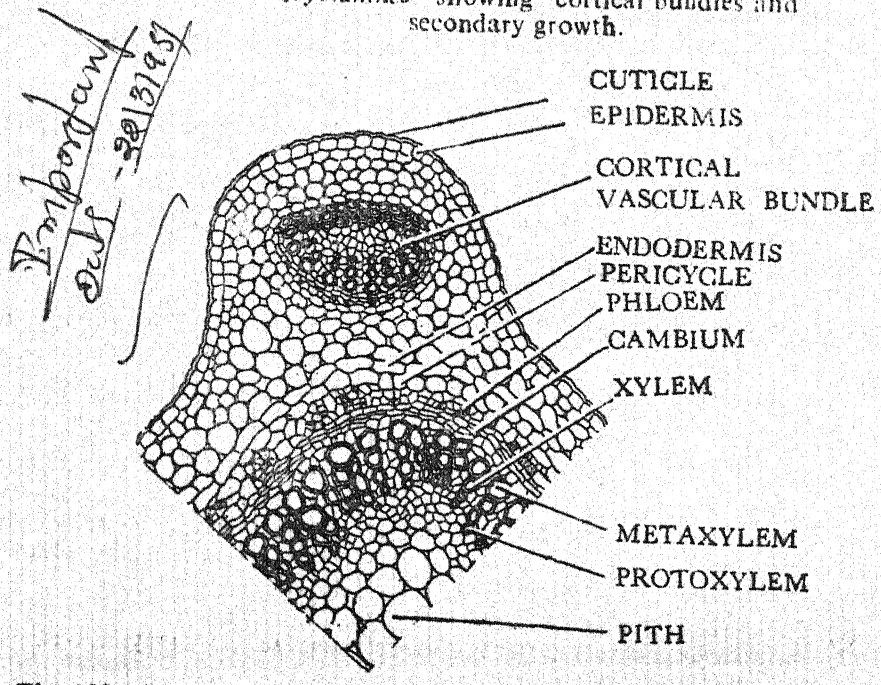


Fig. 103. A portion of the t. s. of the stem of *Nyctanthes* showing cortical bundle in the ridge and normal secondary growth in the stelar region.

Identification

1. Primary vascular bundles conjotnt, collateral, open, endarch and in a ring.

2. Epidermis with cuticle, stomata, and multicellular hairs.

3. Presence of chlorenchyma in the cortex.

4. Small cortex, large stele and large pith.

5. Presence of secondary tissues.

6. Presence of four cortical vascular bundles which are inversely oriented.

STEM OF CASUARINA (Casuarinaceae)

(1) In a t. s. the stem of *Casaurina* shows prominent ridges and furrows.

(2) Epidermis is single layered. Cuticle (silica) is present on the outer walls. Stomata are present in the furrows and are guarded by hairs.

(3) In the ridges, internal to the epidermis, is T-shaped sclerenchyma. Opposite furrows, hyprodermis is collenchamatous.

(4) Outer cortex (in ridges) is composed of palisade parenchyma. Inner cortex is parenchyamatous.

(5) In the parenchymatous inner cortex, in the region of the ridges, collateral and endarch vascular bundles are present corresponding to the number of the ridges. These are *cortical vascular bundles.*

(6) Endodermis is single layered.

(7) Pericycle is multilayered. It is composed of parenchymatous cells with patches of sclerenchyma above phloem region of the vascular bundles.

(8) The primary vascular bundles of the stelar region are conjoint, collateral, open, endarch and arranged in a ring [if secondary growth is absent]

(9) If secondary growth has taken place, a ring of cambium is seen.

(10) This ring forms secondary xylem internally and secondary phloem externally.

(11) Well developed medullary rays are present composed of thinwalled radially elongated cells.

(12) In the centre there is a pith composed of parenchyma. Tanin cells are also present.

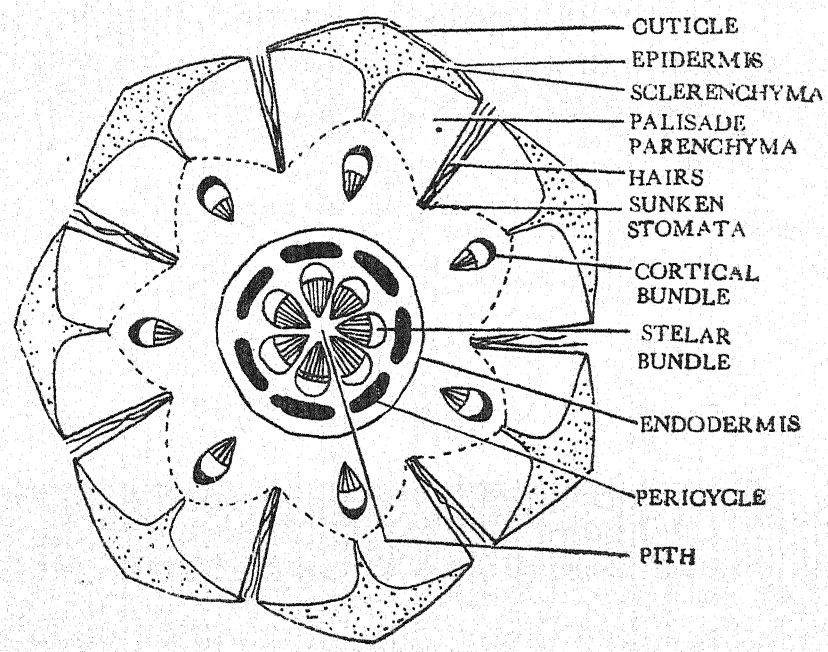


Fig. 104. Diagrammatic structure of the t. s. of stem of *Casuarina* showing cortical vascular bundles.

Identification

It is a dicot stem because :

1. Primary vascular bundles are conjoint, collateral, open, endarch and in a ring.
2. Palisade parenchyma is present in the cortex.
3. Cuticle and stomata present on the epidermis.
4. Secondary tissues are present.
5. Presence of cortical bundles.

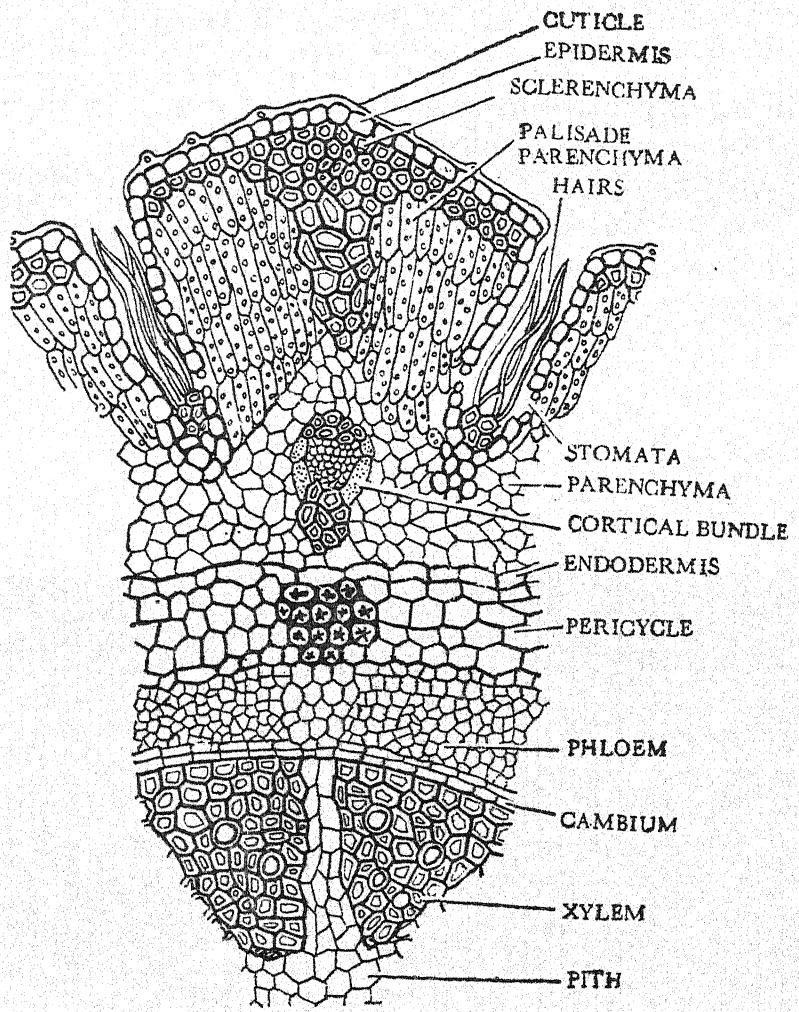


Fig. 105. A portion of the t. s. of the stem of *Casuarina* showing cortical bundles and xerophytic characters.

Xerophytic Characters

1. Thick cuticle, stomata in the furrows and stomata guarded by hairs.
2. Presence of sclerenchyma in the cortex.
3. Presence of palisade parenchyma in the cortex (leaves reduced). The stem is photosynthetic in nature.
4. Presence of sclerenchyma (fibres) in the pericycle.

STEM OF ARGYERIA (Convolvulaceae)

Prepare a double stained glycerine mount of the t. s. of the stem of *Argyeria*. Examine and sketch under low and high powers of the microscope. Note the presence of patches of intraxylary phloem and also the presence of following 4 types of primary vascular bundles scattered in the pith :

(i) Normal conjoint, collateral, open and endarch bundles.

(ii) Inversely oriented conjoint, colloteral open and exarch bundles.

(iii) Bicollateral vascular bundles with central xylem, outer and inner cambium and outer and inner phloem.

(iv) Amphivasal vascular bundles where phloem is surrounded by xylem.

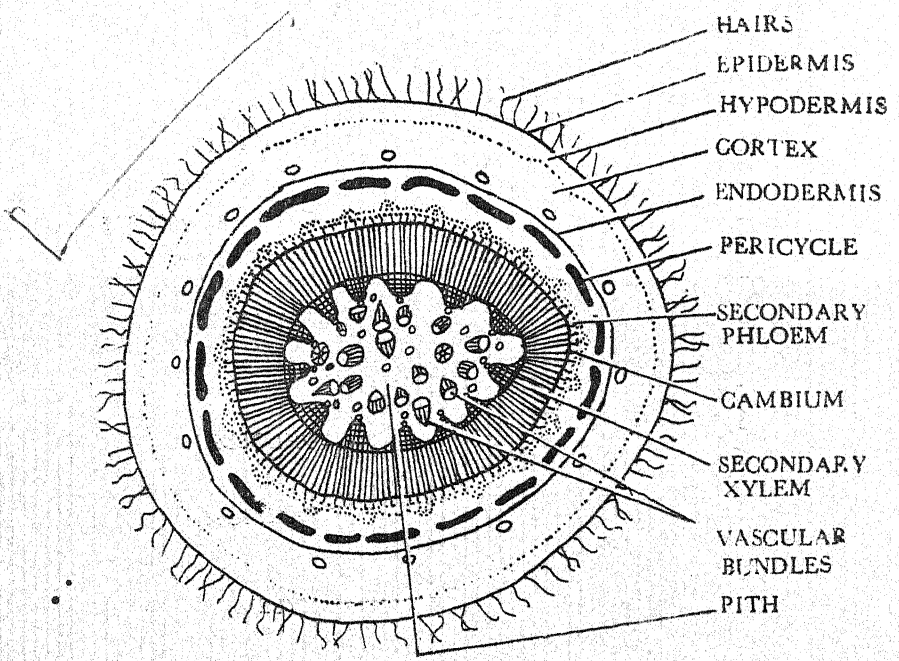


Fig. 106. Diagrammatic structure of the t. s. of the stem of *Argyeria* showing endarch, exarch, bicollateral and amphivasal vascular bundles scattered in the pith.

(1) The outline of the stem in a t. s. is more or less circular and shows the presence of a large number of multicellular hairs on the epidermis, the outermost layer. Cuticle is also present.

(2) It is differentiated into the cortex and the stele.

(3) There is a large parenchymatous pith in the centre containing 4 different types of primary medullary vascular bundles.

(4) Isolated patches of intraxylary phloem are also seen in the peripheral region of the pith.

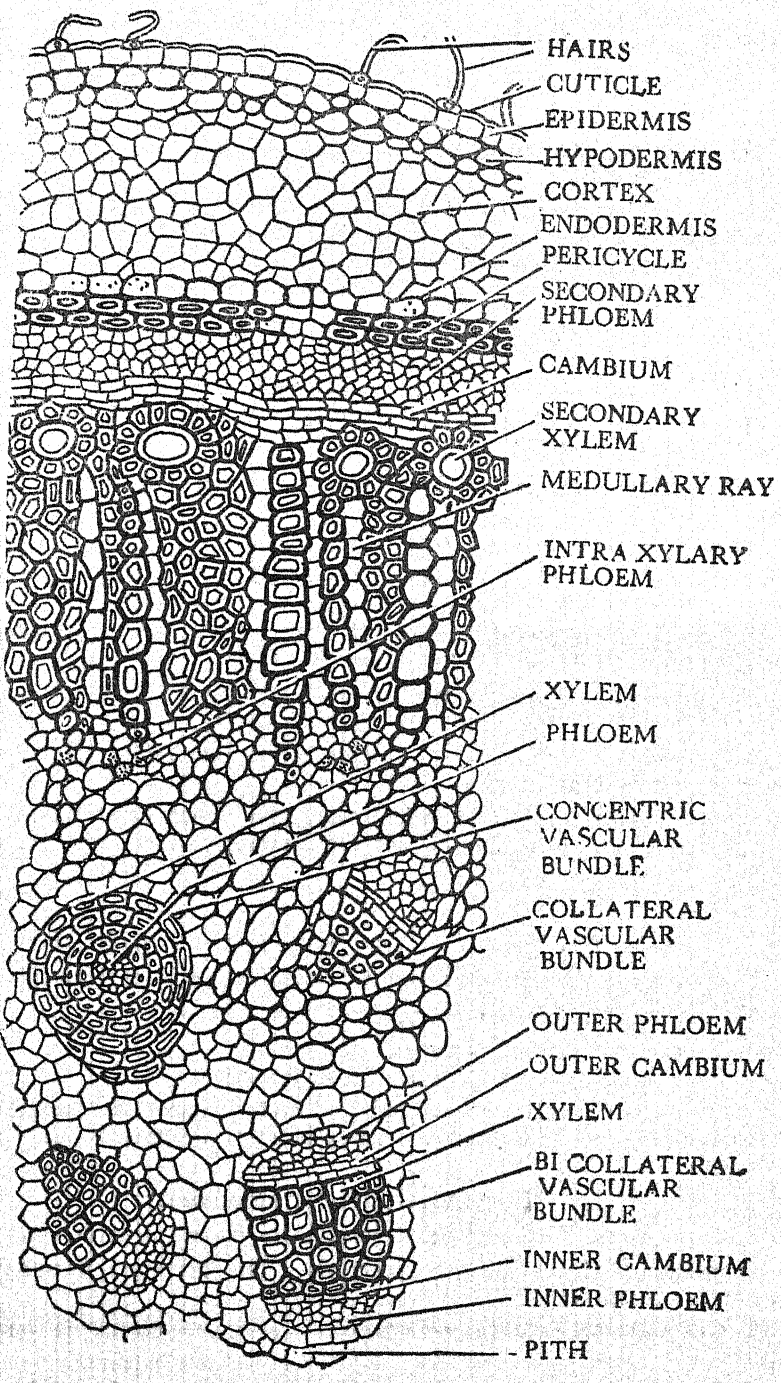


Fig. 107. A portion of the t. s. of the stem of *Argyeria* under the microscope showing detailed structures.

(5) Hypodermis is collenchymatous.

(6) Endodermis is single layered and after secondary growth it is not well marked.

(7) Pericycle is multilayered. It is composed of parenchyma and sclerenchyma (fibres).

(8) Internal to the pericycle there is a continuous zone of secondary phloem (primary phloem being crushed). It is composed of sieve tubes, companion cells and phloem parenchyma.

(9) Internal to it is the cambium ring.

(10) Internal to the cambium ring is a well developed zone of secondary xylem consisting of vessels, tracheids and xylem parenchyma.

(11) Secondary medullary rays are also seen.

(12) Internal to the secondary xylem, primary xylem bundles are present. Each primary xylem bundle is endarch.

(13) Patches of intraxylary phloem are present in the peripheral region of the pith.

(14) Pith is parenchymatous and contains a few secretary cells also.

(15) A number of primary medullary bundles are seen scattered in the pith. These bundles are of four types :

(i) Conjoint, collateral, open and endarch, the normal dicot stem bundles.

(ii) Conjoint, collateral, open and exarch, the inversely oriented bundles.

(iii) Concentric bundles where phloem is surrounded by xylem. These are amphivasal vascular bundles.

(iv) Bicollateral bundles in which outer and inner cambium present at both the ends of the xylem and outside the cambium, outer and inner phloem is present.

Identification

(1) Presence of conjoint, collateral, open and endarch bundles.

(2) Presence of thick cuticle and multicellular hairs on the epidermis.

(3) Small cortex, large stele and large pith.

(4) Presence of secondary tissues.

(5) Presence of patches of intraxylary phloem.

(6) Presence of bicollateral, amphivasal and inversely oriented bundles apart from normal endarch bundles. These bundles are present in the pith and are scattered.

STEM OF SALVADORA (Salvadoraceae)

(1) In a t. s. the outline of the stem is more or less circular.

(2) Outermost layer is the epidermis. The cells are barrel-shaped. There is a thick cuticle

(3) Outer cortex is chlorenchymatous and inner cortex is parenchymatous.

(4) Endodermis is single layered. The cells are barrel-shaped.

(5) Pericycle is multilayered. It is parenchymatous with patches of sclerenchyma fibres embedded in it.

(6) Internal to pericycle there is a continuous ring of secondary phloem consisting of sieve tubes, companion cells and phloem parenchyma. Primary xylem is crushed.

(7) Cambium is seen in the form of a complete ring internal to the secondary phloem and external to the secondary xylem.

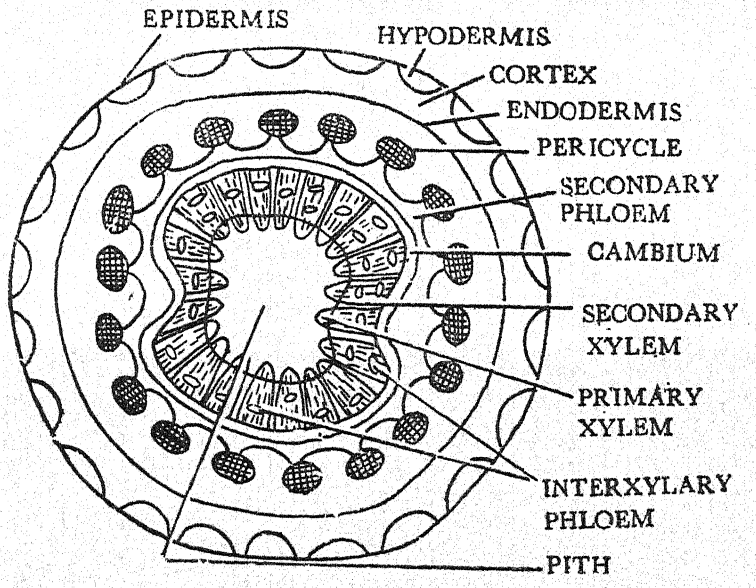


Fig. 108. Diagrammatic structure of t. s. of the stem of *Salvadora* showing patches of interxylary phloem and anomalous secondary growth.

(8) Secondary xylem is in the form of a well developed ring or cylinder. It is composed of vessels, tracheids and parenchyma. Medullary rays are also seen.

(9) Internal to it is primary endarch xylem.

(30) Patches of secondary phloem are seen embedded in the secondary xylem. These are called *included phloem or interxylary phloem.*

(11) Pith is parenchymatous and quite large.

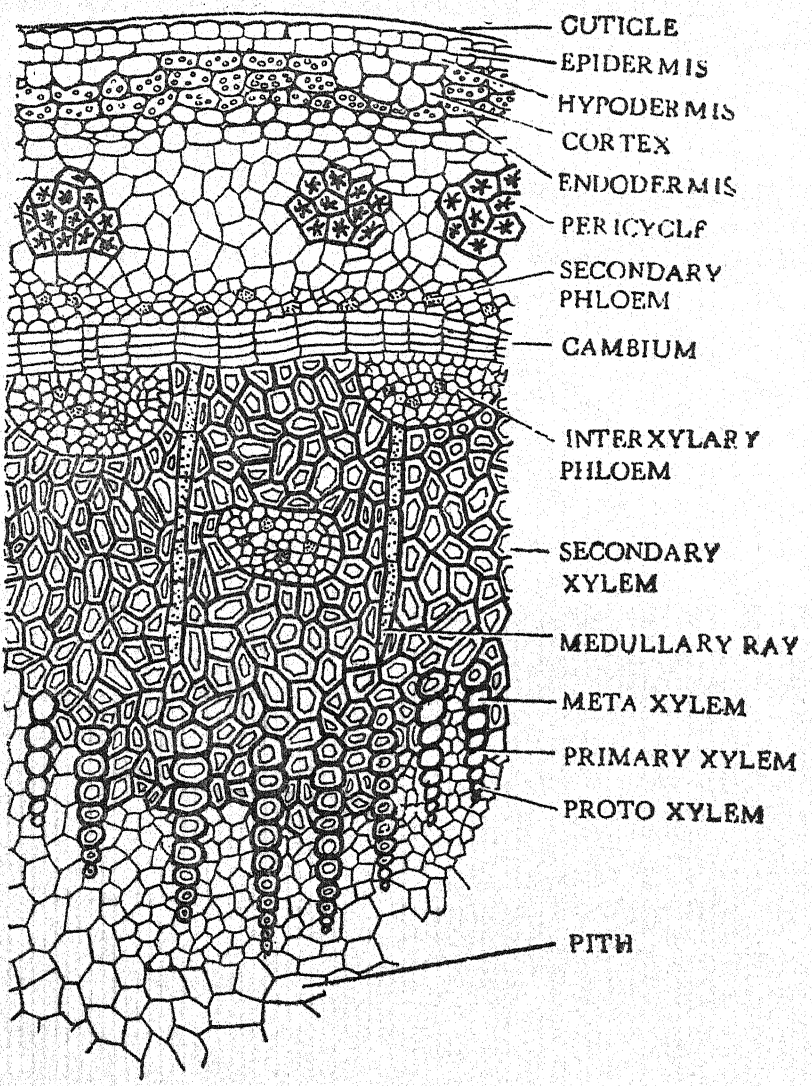


Fig. 109. A portion of the t. s. of the stem of *Salvadora* showing anomalous secondary growth and patches of secondary interxylary phloem embedded in the secondary xylem.

Identification

It is a dicot stem because :

1. Primary vascular bundles are conjoint, collateral, open, endarch and arranged in a ring.
2. Small cortex, large stele and large pith present.
3. Presence of secondary tissues.

4. Presence of chlorenchyma in the cortex
5. Presence of sclerenchyma patches in the pericycle.

Abnormality

1. Presence of interxylary or included phloem in the secondary xylem.

2. In the beginning the secondary growth is normal. The cambium ring forms secondary phloem externally and secondary xylem internally.

After some time, at places, the lower layer of the cambium ring becomes abnormal in function. It cuts off secondary phloem internally and again reverts back to its normal activity. As a result to this patches of secondary phloem are seen embedded in the secondary xylem. This process is repeated at intervals.

STEM OF LEPTADENIA (Asclepiadaceae)

(1) The outline of the stem in a transverse section is more or less circular.

(2) Outermost layer is the epidermis. There is thick cuticle.

(3) Hypodermis is collenchymatous.

(4) Outer cortex is chlorenchymatous and inner cortex is parenchymatous.

(5) Endodermis is single layered. The cells are barrel-shaped.

(6) Pericycle is multilayered. It is parenchymatous with patches of sclerenchyma fibres.

(7) Internal to the pericycle is a continuous ring of secondary phloem composed of sieve tubes, companion cells and phloem parenchyma. Primary phloem is not seen.

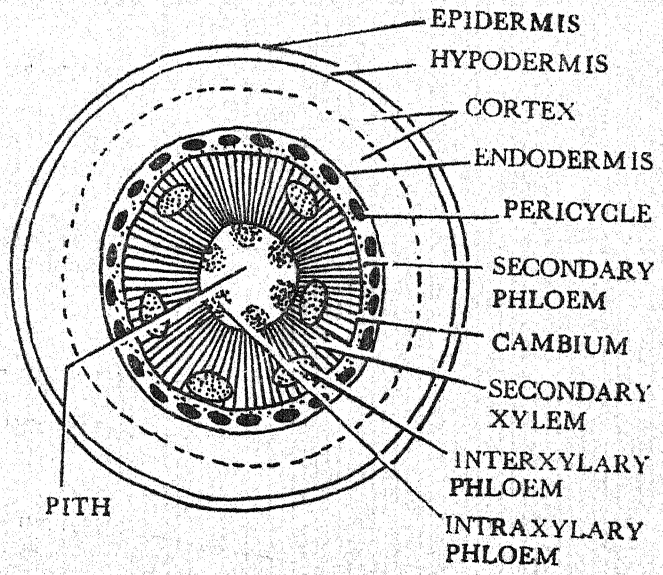


Fig. 110. Diagrammatic structure of the t.s. of the stem of *Leptadenia* showing abnormal secondary growth. Patches of interxylary or included phloem are seen embedded in the secondary xylem. In the peripheral region of the pith patches of intraxylary phloem are also present. The central pith gets reduced due the formation of secondary xylem in the sletar region.

(8) Internal to secondary phloem is a ring of cambium.

(9) Internal to cambium ring is well developed zone of secondary xylem. Patches of included phloem or interxylary phloem are present in it. Xylem is composed of large vessels, tracheids and parenchyma.

(10) Medullary rays, composed of thinwalled radially elongated cells, are seen in the xylem.

(11) Internal to the secondary xylem is endarch primary xylem.

(12) The central region is occupied by parenchymatous pith with patches of intraxylary phloem, in the peripheral region, internal to the primary xylem.

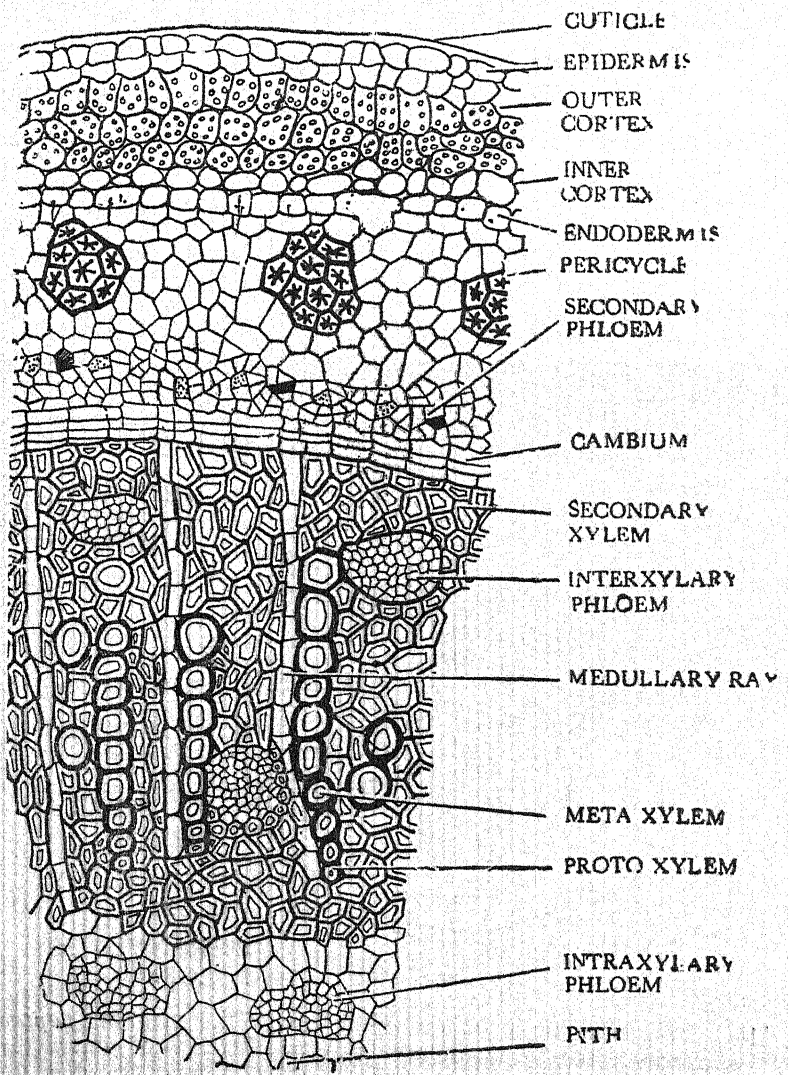


Fig. 111. A portion of the cellular structure of the t.s. of the stem of *Leptadenia* showing patches of interxylary and intraxylary phloem.

Identification

1. Primary vascular bundles are conjoint, collateral, open and endarch. They are arranged in a ring.
2. Small cortex and large stele.
3. Presence of secondary tissues.
4. Presence of chlorenchyma in the cortex.
5. Presence of intraxylary phloem and interxylary phloem.

Abnormality

1. Presence of interxylary phloem or included phloem embedded in the secondary xylem and also patches of intraxylary phloem in the peripheral region of the pith.
2. The formation of interxylary secondary phloem resembles that of *Salvadora*.

Xerophytic Characters

1. Thick cuticle.
2. Presence of chlorenchyma.
3. Presence of sclerenchyma patches.
4. Well developed secondary xylem.

STEM OF STRYCHNOS (Loganiaceae)

(1) The outline of the stem in a t. s. is circular.

(2) Outermost layer is the epidermis with thick cuticle.

(3) Hypodermis is collenchymatous.

(4) Outer cortex is chlorenchymatous and the inner cortex is parenchymatous.

(5) Endodermis is single layered composed of thinwalled parenchymatous barrel-shaped cells.

(6) Pericycle is multilayered (2-3) and is composed of thick walled sclerenchyma fibres or stone cells.

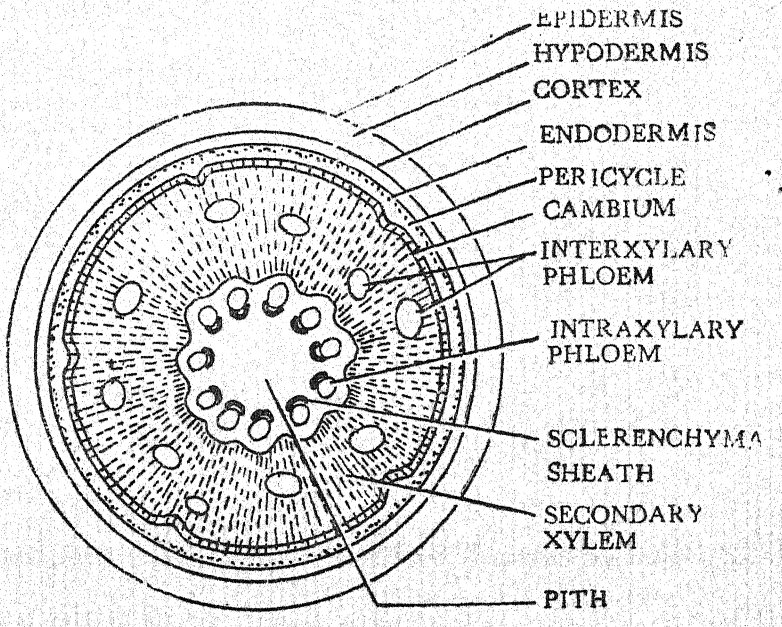


Fig. 112. Diagrammatic structure of the t. s. of stem of *Strychnos nux-vomica*.

(7) Internal to the pericycle there is a complete cylinder of secondary phloem.

(8) Internal to secondary phloem is the cambium ring.

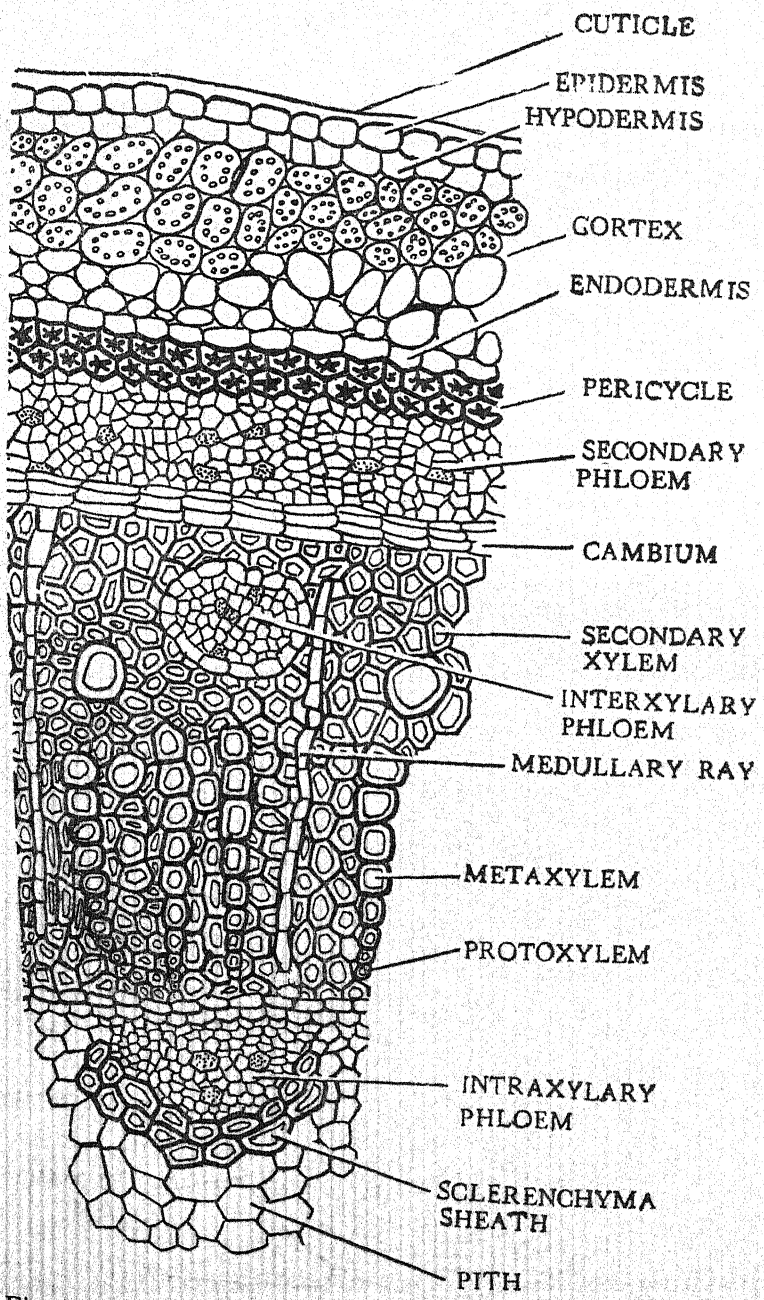


Fig. 113. A portion of the t. s. of the stem of *Strychnos nux-vomica* showing interxylary and intraxylary phloem.

(9) Internal to the cambium ring is a broad zone of secondary xylem. Patches of secondary interxylary phloem or included phloem are seen embedded in it. Medullary rays are also seen.

(10) Internal to the secondary xylem is endarch primary xylem.

(11) There is a central pith composed of parenchyma cells.

(12) Patches of intraxylary phloem are present in the peripheral region of the pith.

(13) Sclerenchyma sheaths are present on the inner side of the intraxylary phloem patches.

Identification

1. Primary xylem endarch.
2. Primary vascular bundles conjoint, collateral, open, endarch and in a ring.
3. Secondary growth is seen.
4. Cortex small and large stele.
5. Presence of chlorenchyma in the cortex.
6. Presence of intraxylary phloem.
7. Presence of intraxylary phloem with sclerenchyma sheath on the inner side.

Xerophytic Characters

1. Thick cuticle.
2. Chlorenchyma in the cortex.
3. Pericycle sclerenchymatous (fibres or stone cells).
4. Well developed secondary xylem.
5. Presence of sclerenchyma sheath on the inner sides of the intraxylary phloem in the pith.

Abnormality

1. Presence of intraxylary phloem in the peripheral region of the pith.

2. Presence of patches of intraxylary phloem included or embedded in the secondary xylem.

3. The formation of intraxylary phloem in *Strychnos* is different from *Salvadora*. In *Strychnos* cambium starts functioning in the normal way. After some time small segments of the cambium ring become inactive. New strips of cambium (secondary cambium) arise opposite the previous inactive strips some where in the pericycle or the phloem. The original active cambium joins the strips of secondary cambium. Now the cambium ring becomes complete and here and there encloses patches of secondary parenchyma. The cambium forms secondary xylem internally and thus patches of secondary phloem are seen embedded in secondary xylem.

Examine and sketch the permant slides showing ;

(i) Inulin crystals

(ii) Isoblasts
(iii) Latex cells and latex vessels
(iv) Lenticel
(v) Types of stomata

ROOT TUBER OF DAHLIA WITH INULIN

(1) This is a section of root-tuber of *Dahlia* (Compositae) showing inulin crystals in the cells.

(2) Inulin crystals are beautiful fan-shaped crystals.

(3) It is a polysaccharide carbohydrate.

(4) Innulin is precipitated by treatment with alcohol or glycerine.

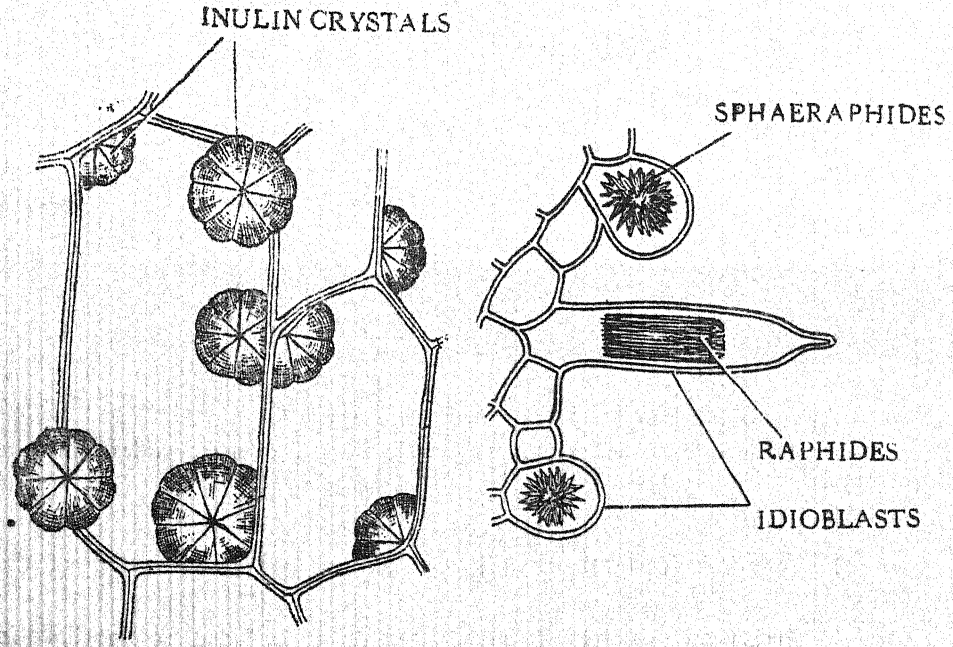


Fig. 114. Two cells of root-tuber of *Dahlia* showing inulin crystals.

Fig. 115. Cells of *Pistia* leaf showing raphides and sphaeraphides.

RAPHIDES AND SPHAERAPHIDES OF PISTIA

(1) *Pistia* is a hydrophyte belonging to the family Araceae. Some of the cells of the leaves contain crystals.

(2) Needle-like or acicular crystals (*raphides*) in the form of bundles are found in special mucilage containing cells called *idioblasts*.

(3) When these crystals produce rounhish crystal aggregates, they are called *sphaeraphides.*

(4) These crystals are of calcium oxalate.

LATICIFEROUS DUCTS

(1) These are long tube like bodies containing viscous fluid, the latex.

(2) The latex is usually milky and comes out readily when the plant is injured.

(3) In *Euphorbia* (Euphorbiaceae) the laticiferous ducts are simple, non-articulate and are called ***latex cells*** (A).

(4) In *Carica papaya* (Caricaceae) the laticiferous ducts are compound, articulate and are called ***latex vessels*** (B).

(5) Latex cells and latex vessels are coenocytic cells.

(6) Presence of laticiferous duct is a xerophytic character.

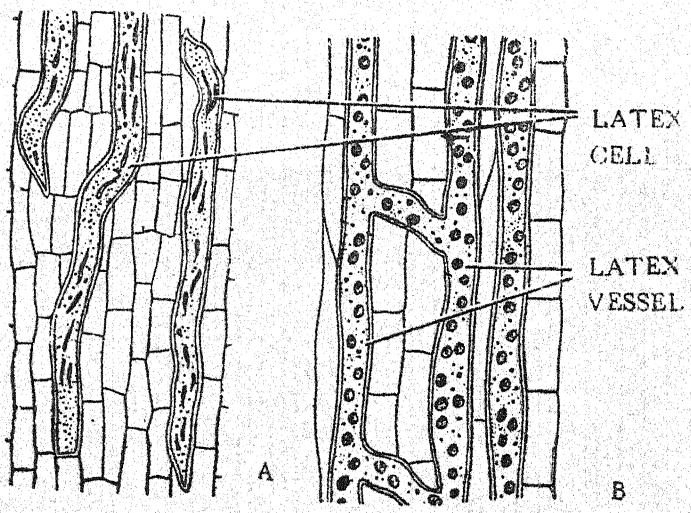


Fig. 116. Showing laticiferous ducts. A. latex cells of *Euphorbia*. B. Latex vessels of *Carica papaya.*

LENTICEL

(1) This slide is showing ***lenticel.***

(2) Lenticel is formed due to secondary growth in the cortex.

(3) In the extreme periphery the cells form ***cork cambium ring.***

(4) The cork cambium forms thick-walled suberised rectangular cells externally, the ***cork.***

(5) Internally it forms secondary cortex of ***chlorenchymatous cells.***

(6) Opposite stomata, the cork cambium forms loose thin-wall parenchyma cells called ***complementary cells.***

(7) Due to formation of complementary cells the epidermis is ruptured.

(8) The lenticel helps in gaseous exchange.

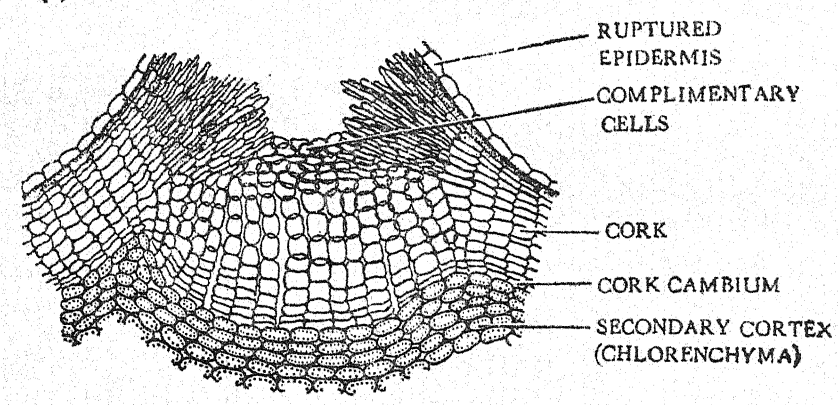


Fig. 117. Showing a well formed lenticel as seen in a t. s.

Types of Stomata

(1) This slide is showing four types of stomata :

(A) Anomocytic (*Clematis*—Ranunculaceae).

(B) Anisocytic (*Iberis*—Cruciferae).

(C) Diacytic (*Dianthus*—Caryophyllaceae).

(D) Paracytic (*Gardenia*—Rubiaceae).

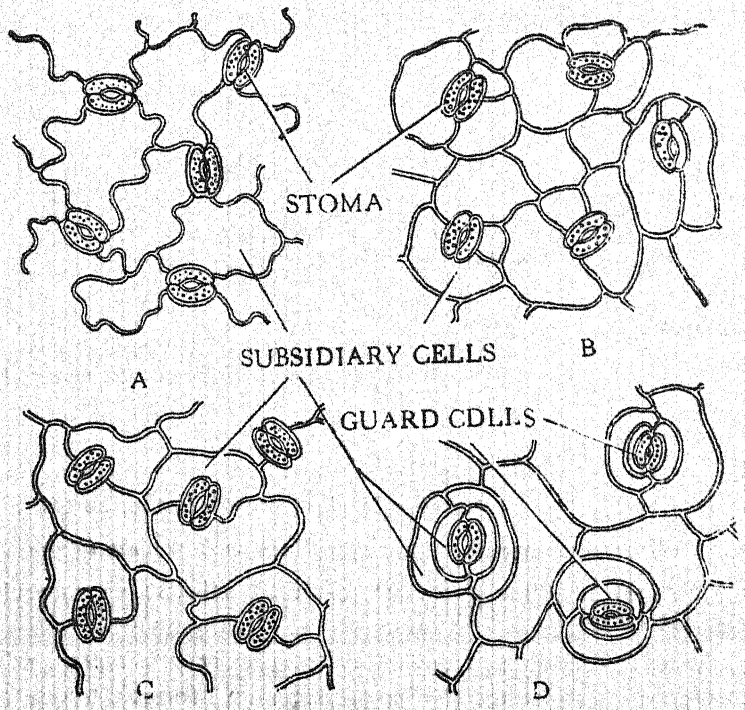


Fig. 118. Showing 4 types of stomata.

A. Ranunculous Type

(1) It is irregular-celled type (*Anomocytic*).

(2) Stoma remain surrounded by limited number of cells.

(3) There is no differentiation between epidermal and subsidiary cells.

B. Cruciferous Type

(1) This is unequal-celled type (*Anisocytic*).

(2) Here the stoma are surrounded by 3 cells (2 larger subsidiary cells and one small subsidiary cell).

C. Caryophyllaceous Type

(1) It is cross-celled type (*Diacytic*).

(2) Stomata are surrounded by a pair of subsidiary cells.

(3) The common wall of the subsidiary cells is at right angles to the guard cells.

D. Rubiaceous Type

(1) It is parallel-celled type (*Paracytic*).

(2) The stomata is accompanied by one or more subsidiary cells.

(3) The subsidiary cells lie parallel to the long axis of the pore of the guard cells.

CHAPTER 3
Embryology

Examine and sketch the following permanent slides ;

(i) L. S. of flower showing the different floral members.

(ii) T. S. of a young anther showing developing microsporangia.

(iii) A portion of the t. s. of anther showing young microsporangium. Parietal layer, tapetum and pollen mother cells are well marked.

(iv) T. S. of a mature anther showing dehiscence.

(v) Whole mount of the pollinia of *Calotropis*.

(vi) Pollen grains germinating on the surface of the stigma.

L. S. OF FLOWER

(1) This slide is showing l. s. of a hypogynous flower.

(2) All the four floral members i. e. sepals, petals, stamens and carpels are seen.

(3) The receptacle is convex and the ovary is placed above the other floral members. The flower is *hypogynous* and the ovary is *superior*.

(4) Ovules are attached on the placenta inside the ovary. Three ovules are seen in each locule.

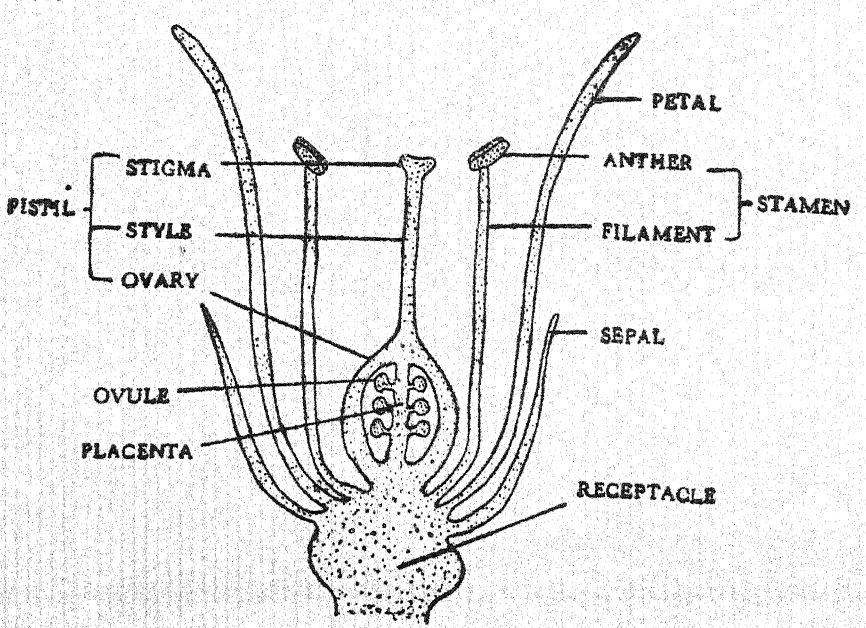


Fig. 119. L. S. of a flower showing sepals, petals, stamens and the pistil.

T. S. OF A YOUNG ANTHER

(1) This is a slide showing t. s. of a young anther.

(2) The four corners are bulging-out due to the development of microsporangia.

(3) The microsporangium is not fully developed. Only parietal (wall) layer and sporogenous cells are marked.

(4) There is a vascular bundle (connective) in the centre of the anther.

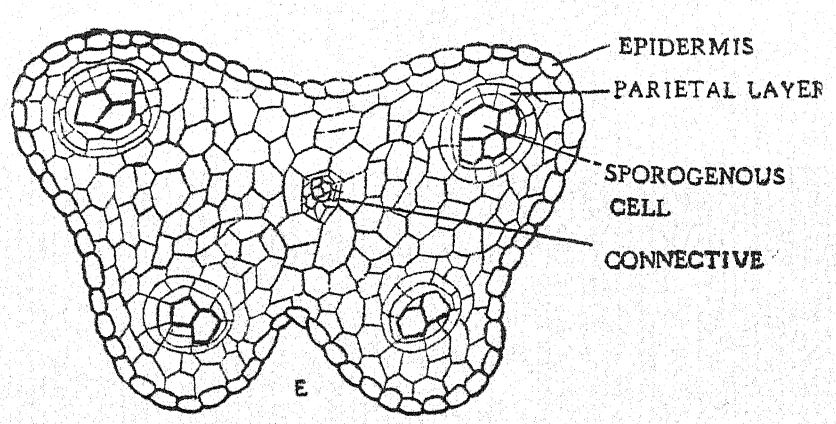


Fig. 120. T. S. of a young anther showing microsporangia in early stage of development.

T. S. OF AHTHER SHOWING TAPETUM

(1) This is a slide of t. s. of anther showing developing microsporangium.

(2) The anther lobes are well marked.

(3) Each microsporangium is surrounded by 3 layered wall.

(4) The innermost wall layer is nutritive in function and is known as tapetum.

(5) In the centre compact polygonal cells are present. These are called pollen mother cells which form pollen grains.

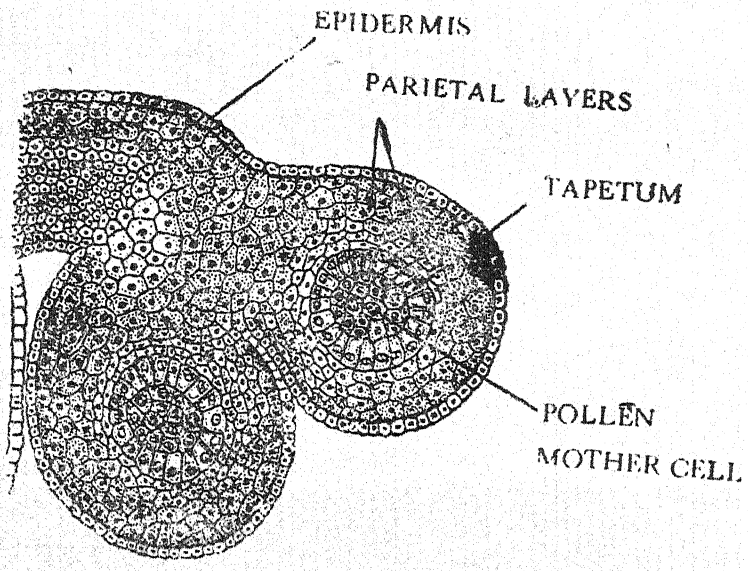


Fig. 121. A portion of the t. s. of anther showing 2 developing microsporangia. Tapetum is well marked.

T. S. OF A MATURE ANTHER

(1) This is a slide of t. s. of a mature anther.

(2) The anther is bithecous and each theca contains two microsporangia or pollen chambers (sacs).

(3) The middle cells of the two sacs of one theca is disintegrated and thus the two sacs become one.

(4) Each microsporangium has a three layered wall.

(5) The outermost wall or *endothecium* is fibrous. The middle walls are crushed and the *tapetum* or the nutritive layer is disorganised.

(6) Pollen sacs contain a large number of uninucleate pollen grains.

(7) The dehiscence of the anther takes place through pores.

(8) The pores are formed along specialised cells in the wall known as *stomium*.

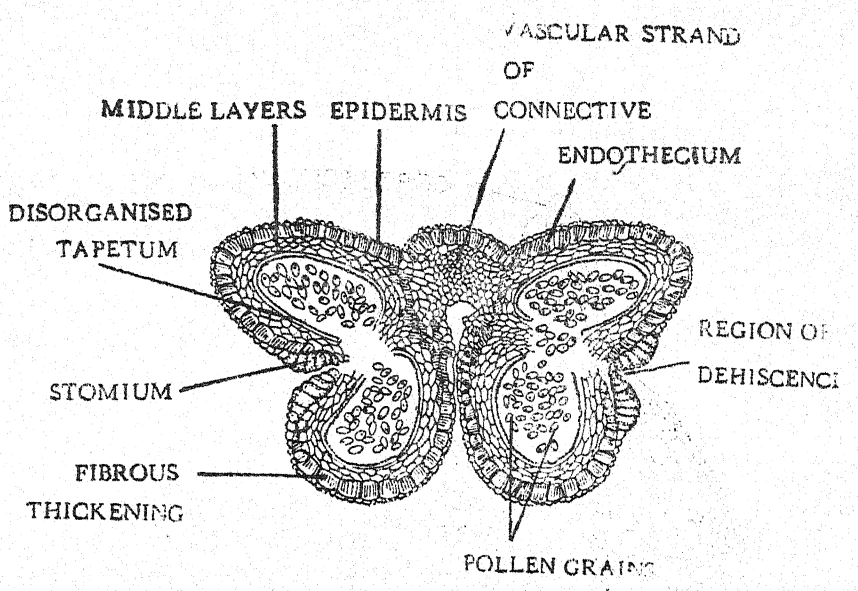


Fig. 122. T. S. of a mature anther showing dehiscence.

POLLINIA OF CALOTROPIS

(i) Take out the *pollinia* of *Calotropis* flower from its gynostegium with the help of a forceps. Mount it in glycerine and examine and sketch under the microscope.

(ii) Examine and sketch the permanent slide of pollinia of *Calotropis* under the microscope.

(1) The flower of *Calotropis* (Asclepiadaceae) are provided with characteristic *gynostegium*.

(2) Gynostegium is formed by the union of the stigma with the androecium.

(3) The pollen grains are united (compound pollen grains).

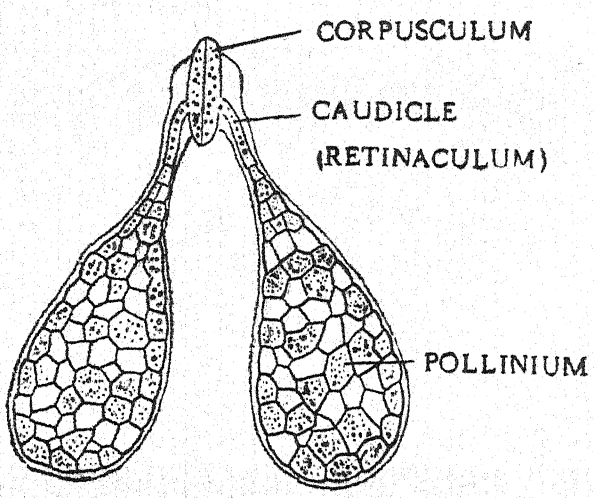
(4) All the pollen grains of each anther lobe form a characteristic mass called *pollinium*.

(5) Each pollinium is provided with a stalk called *caudicle* and a sticky base known as *disc* or *corpusculum*.

(6) Two pollinia from two different anthers are attached (the sticky discs of the two pollinia unite) forming a special structure.

(7) The pollinia because of its sticky corpusculum get stuck to the legs of visiting bees and the pollinia are pulled out.

(8) In this way the pollinia are carried to other flowers by these bees ensuring pollination.



POLLINIA OF

CALOTROPIS

Fig. 123. Pollinia of *Colotropis* showing corpusculum, caudicle and pollinium containing pollen grains.

GERMINATING POLLEN GRAINS

(1) This is a slide showing pollen grains on the stigma (left).

(2) The pollen grains are in different stages of germination on the stigma (right).

(3) The outer wall or exine which is spiny in this case, gets ruptured and the intine comes out as a tube or finger like structure.

(4) This finger like structure is kdown as the pollen tube.

(5) The pollen tube makes its way through styte and reaches the ovule. It carries two male gametes for fertilization.

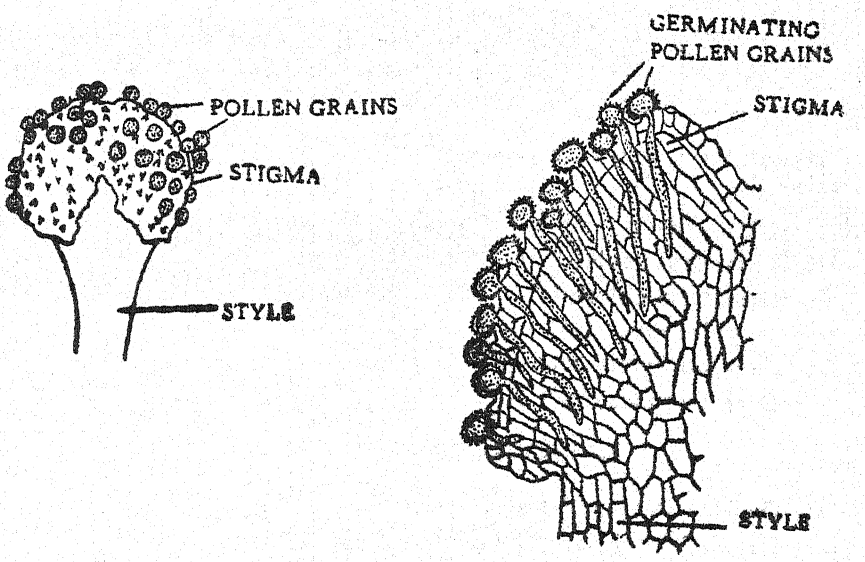


Fig. 124. (A). Slide showing germinating pollen grains.

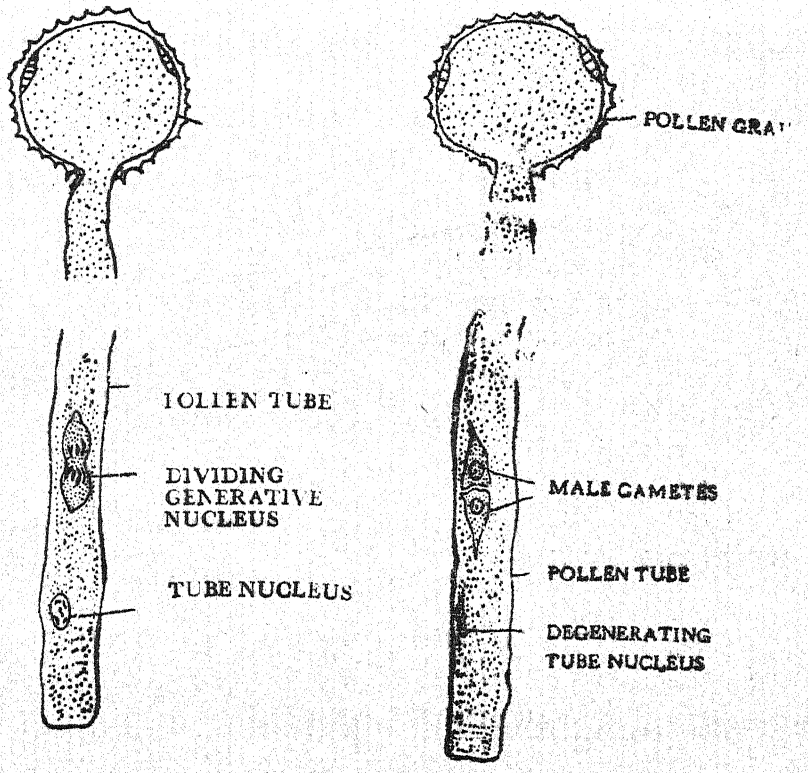


Fig. 124. (B). Two germinating pollengrains from the same slide showing dividing generative nucleus and tube nucleus in the pollen tube (left); and two male gametes and degenerating tube nucleus in another pollen tube (right).

(7) In the high power of the microscope the pollen tubes show the generative and the tube or vegetative nuclei, dividing generative nucleus (take dark stain), male gametes and the degenerating tube nucleus.

Examine and sketch the permanent slides showing the different types of ovules.

(i) Orthrotropous ovule
(ii) Anatropous ovule
(iii) Hemiantropous ovule
(iv) Amphitropous ovule
(v) Campylotropous ovule
(vi) Circinotropous ovule

ORTHOTROPOUS OVULE

(1) Ovule is erect or straight.

(2) The funicle, chalaza and micropyle lie in one vertical line.

(3) The embryosac is 8 nucleate *Polygonum type*.

(4) At the micropylar end there is an egg apparatus (one egg and two synergids), in the centre there is a secondary nucleus and at the chalazal end there are three antipodal cells.

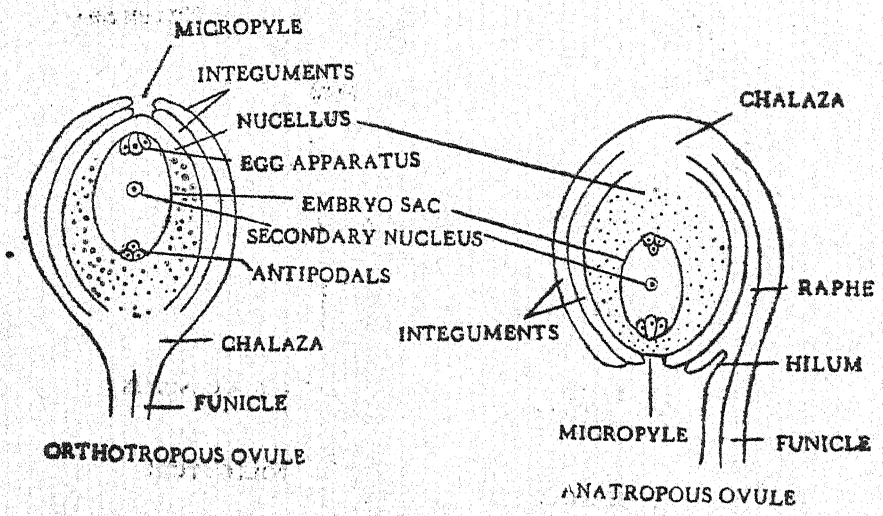


Fig. 125. Showing *Orthoropous* (A) and *Anatropous* (B) ovules.

(5) The ovule is bitegmic.

ANATROPOUS OVULE

(1) It is an inverted ovule.

(2) The inverted ovule is fused with the funicle forming the raphe. The micropyle and the hilum come to lie very close to each other.

(3) The micropyle lies towards the funicle and chalaza on the opposite (upper) side.

(4) This is the most common type of ovule found in the majority of families (sympetalae).

(5) One such common example is *Nymphaea*.

CAMPYLOTROPOUS OVULE

(1) It is a curved ovule.

(2) The micropyle and the chalaza come to lie on either side of the funicle.

(3) The ovule is bitegmic.

(4) The embryo sac is also curved.

(5) This tppe of ovule commonly occurs in the family Leguminosae.

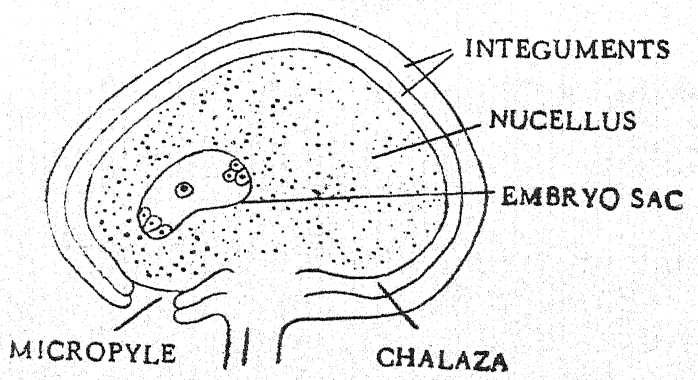


Fig. 126. Showing *Campylotropous type* of ovule.

HEMINATROPOUS OVULE

(1) Here the micropyle and the chalaza lie in one horizontal line.

(2) The nucellus and the integuments lie more or less at right angles to the funiculus.

(3) The embryo sac also lies in a horizontal plane.

(4) Hemianatropous type of ovule is found in *Ranunculus*.

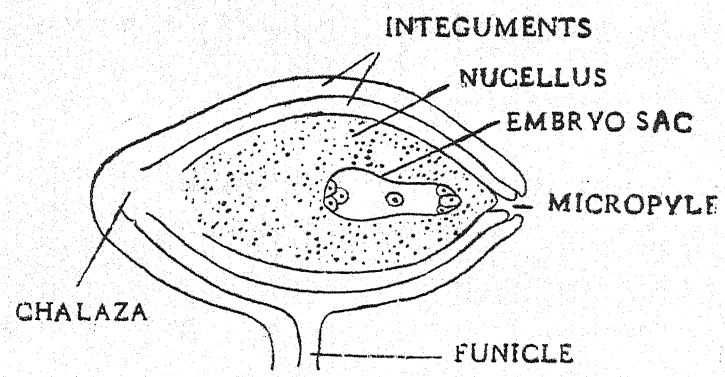


Fig. 127. Showing *Hemianatropous type* of ovule.

AMPHITROPUS OVULE

(1) It has curved embryo and curvature is pronounced.
(2) The embryo sac is also affected.
(3) It becomes horse-shoe-shaped.
(4) This type of ovule is found in Butomaceae.

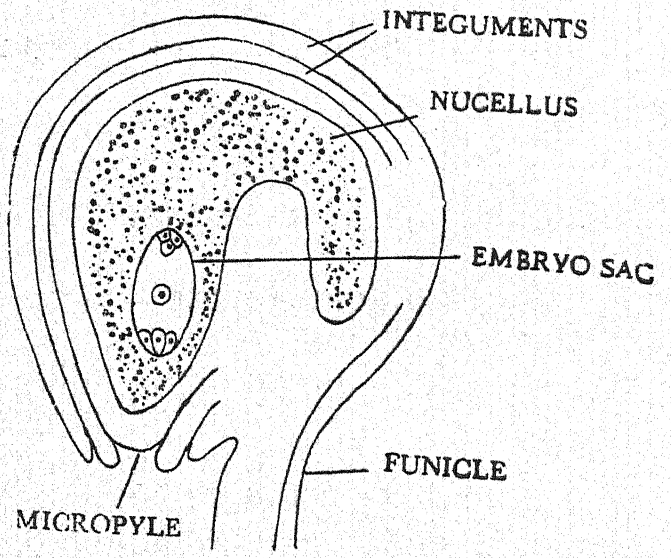


Fig. 128. *Amphitropous ovule.*

CIRCINOTROPOUS OVULE

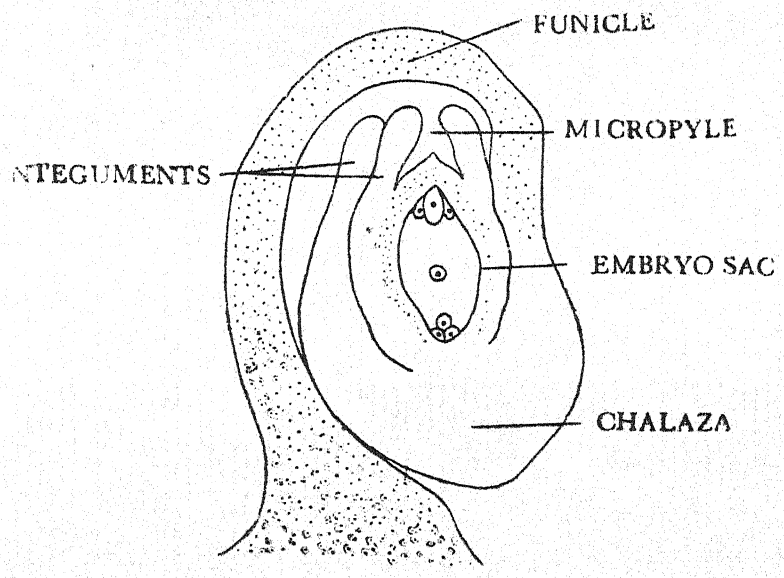
(1) This type of ovule is very peculiar.

(2) Here the nucellar protuberance is at first in the same line as the axis.

(3) The later rapid growth on one side only makes it anatropous.

(4) The curvature continues and finally the ovule is turned over completely and the micropylar end again points upwards.

(5) This type of ovule is found in the family Plumbaginaceae and *Opuntia*.



CIRCINOTROPOUS OVULE

Fig. 129. *Circinotropous* ovule.

Examine and sketch the permanent slide of t. s. of ovule of *Capsella bursa-pastoris* (Cruciferae). Note its characteristic features.

(1) The ovule is *campylotropous*.

(2) The embryosac and the later developed endosperm as well as the embryo are horseshoe-shaped.

(3) The micropyle is pointed downwards and the embryo is upside down.

(4) Ultimately the hypocotyl and the two large colyledons fill the entire cavity of the ovule.

(5) The endoderm is *nuclear*.

(6) The endosperm as well as the nucellus are consumed by the embryo.

(7) The antipodal cells form a tissue and are persistent.

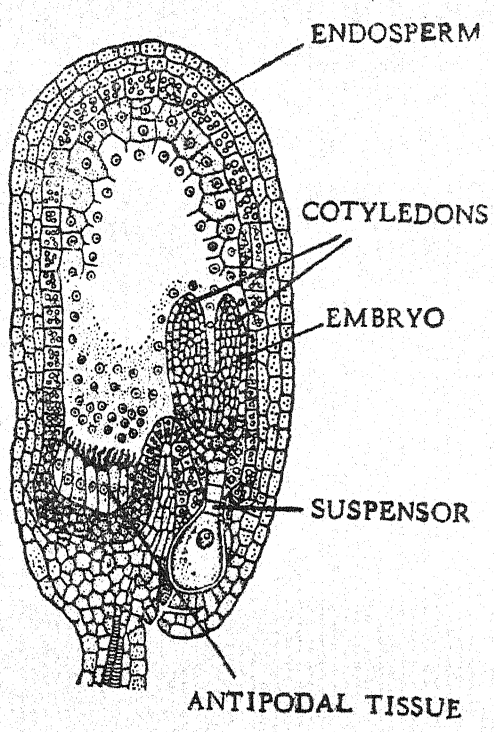


Fig. 130. L. S. of the ovule of *Capsella bursa-pastoris* of the family Cruciferae showing a dicot embryo, nuclear endosperm with a cavity and persistent antipodal tissue at the antipodal end of the embryo sac.

Examine and sketch the permanent slide of t. s. of the ovary of *Lilium* showing embryo sacs in the different stages of development.

(1) In a t. s. the ovary is tricarpellary, syncarpour, trilocular with axile placentation.

(2) Two ovules are seen in each locule attached to the placenta.

(3) The ovules are *anatropous*.

(4) Each ovule is bitegmic and inverted. The micropyle and the hilum come to lie very close to eaeh other.

(5) The embryo sacs are uninucleate, binuucleate, 4-nucleate, 8-nucleate or mature.

[Note : Write only that stage of the embryo sac which is focussed under the microscope].

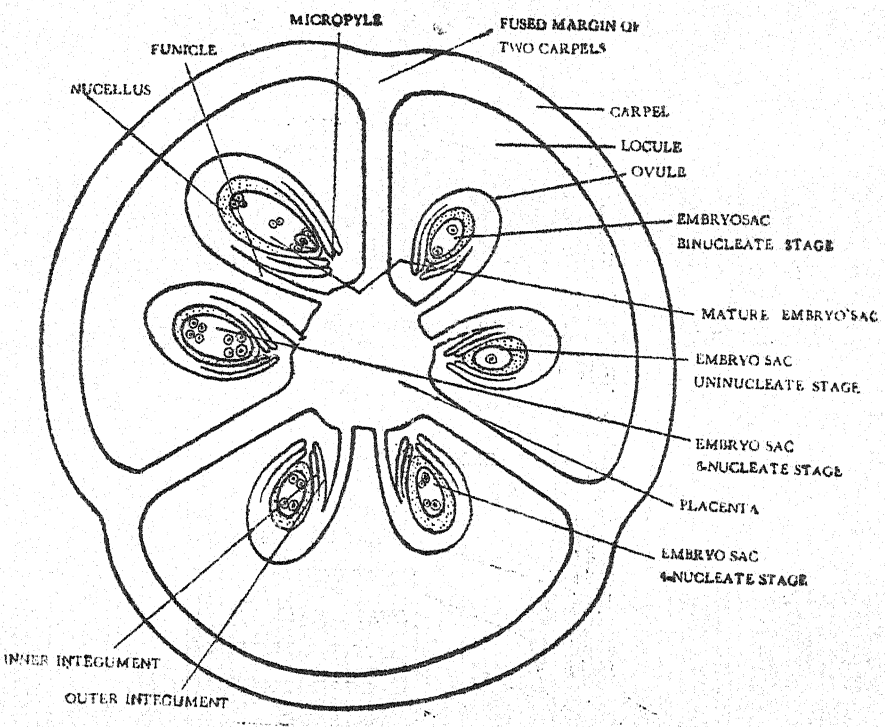


Fig. 131. T. S. of the ovary of *Lilium* showing anatropous ovules and also the embryo sacs at the different stages of development.

Examine and sketch the permanent slides of l. s. of flowers showing porogamy in anatropous and orthrotropous ovules.

POROGAMY IN ORTHOTROPOUS OVULE

(1) This slide shows progromy in an orthotropous ovule.

(2) Porogamy is the entry of the pollen tube into the embryo sac through pore or the micropyle. It passes through the nucellus, wall of the embryo sac and the synergids.

(3) Several pollen grains are seen germinating on the stigma but only one is making its way to reach the embryo sac.

(4) The tip of the pollen grain is broaken as it enters the embryo sac.

(5) Out of the two male gametes, one fertilizes the egg and the other one fuses with the secondary nucleus forming a triploid nutritive ***endosperm***.

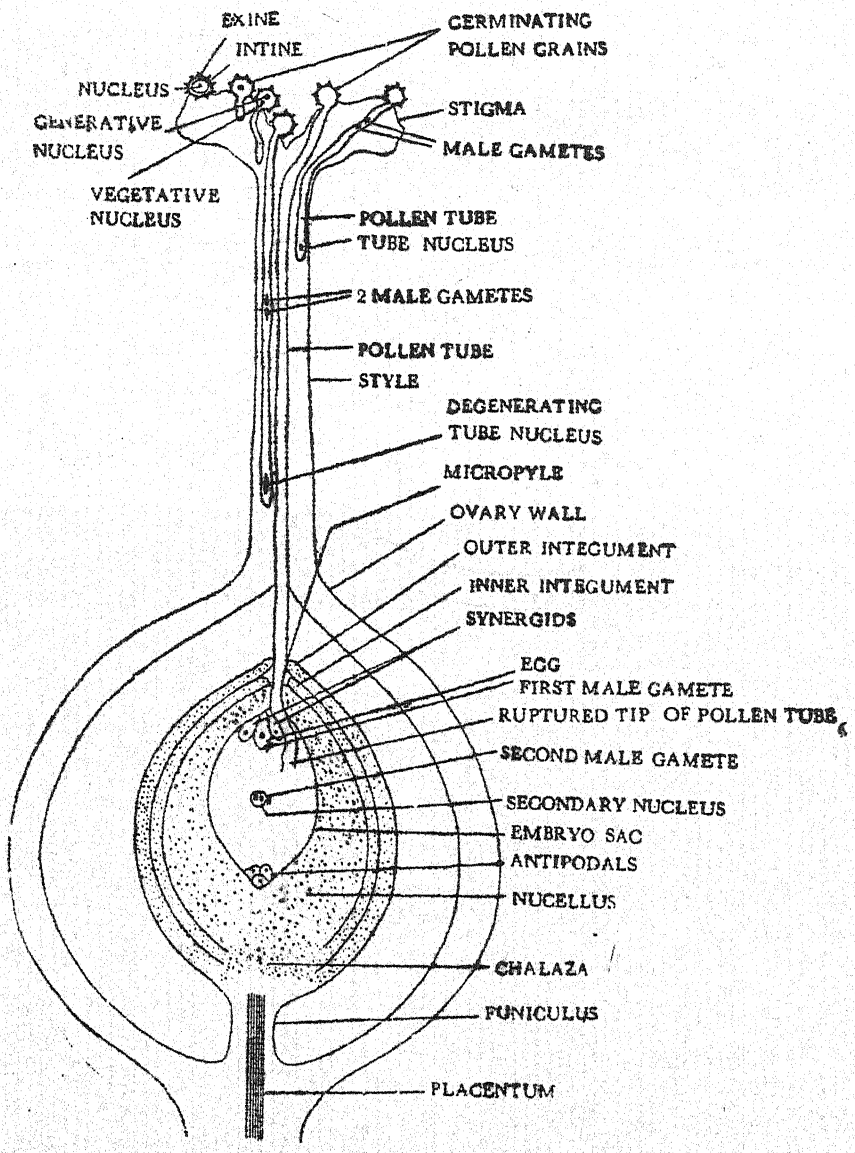


Fig. 132. Showing a number of pollen grains germinating on the stigma. The pollen tubes are at different stages of the development. One pollen tube is seen entering the ovule through the micropyle and ultimately the tip of the pollen tube is ruptured and the two male gamtes are liberated inside the embryo sac.

POROGAMY IN ANATROPOUS OVULE

(1) The ovule is inverted and anatropous type. It is bitegmic.

(2) Three pollen grains are seen germinating on the stigma.

(3) The pollen tube of one of the pollen grains makes its way through the style and reaches the ovule through micropyle.

(4) This is known as porogamy.

(5) The pollen tube is carrying the two male gametes with it.

(6) The embryo sac is eight nucleate and mature.

(7) At the micropylar end there is the 3-celled egg apparatus (one egg and 2 synergids), secondary nucleus (formed by the two polar nuclei) in the centre and 3 antipodal cells at the chalazal end.

(8) The tip of the pollen tube has not made its entry into the embryo sac.

(9) The ovary is hypogynous.

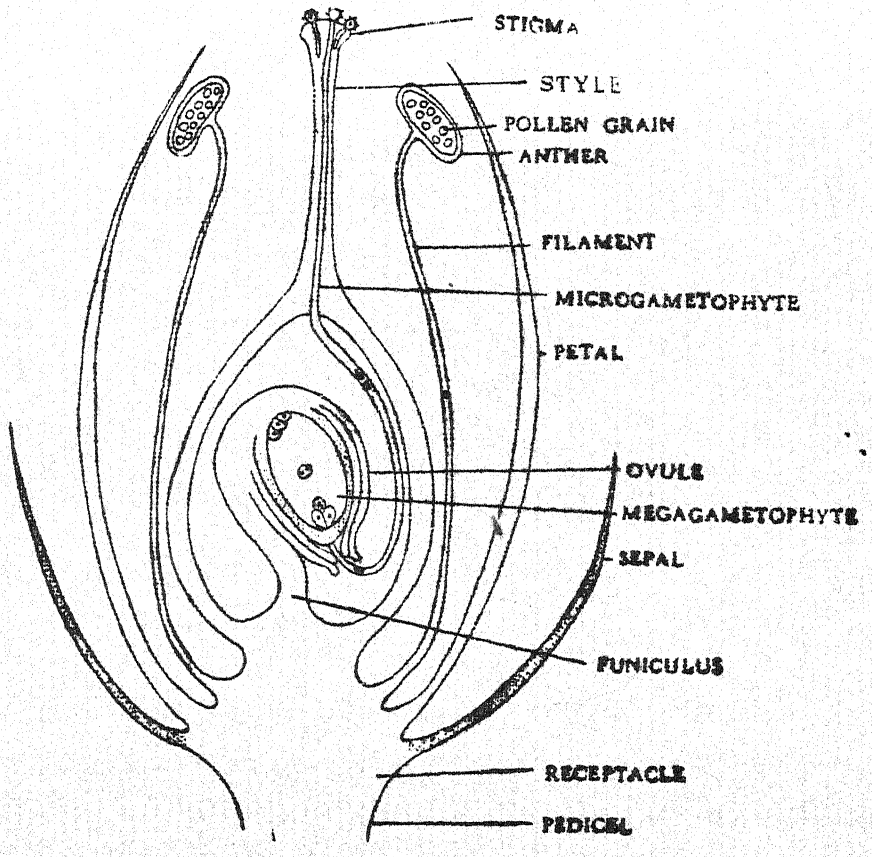


Fig. 133. L. S. of a flower showing porogamy in an anatropous ovule.

Examine and sketch the permanent slides showing endosperm haustoria.

"VERMIFORM APPENDAGE" OF GREVILLEA

(1) This is l. s. of seed of *Grevillea robusta* showing "vermiform appendage."

(2) The endosperm is of nuclear type.

(3) The lower coenocytic part of the endosperm grows in the form of a coiled and tubular worm-like structure.

(4) This structure is called "vermiform appendage."

(5) It serves as a haustorium and sucks up food from the chalaza.

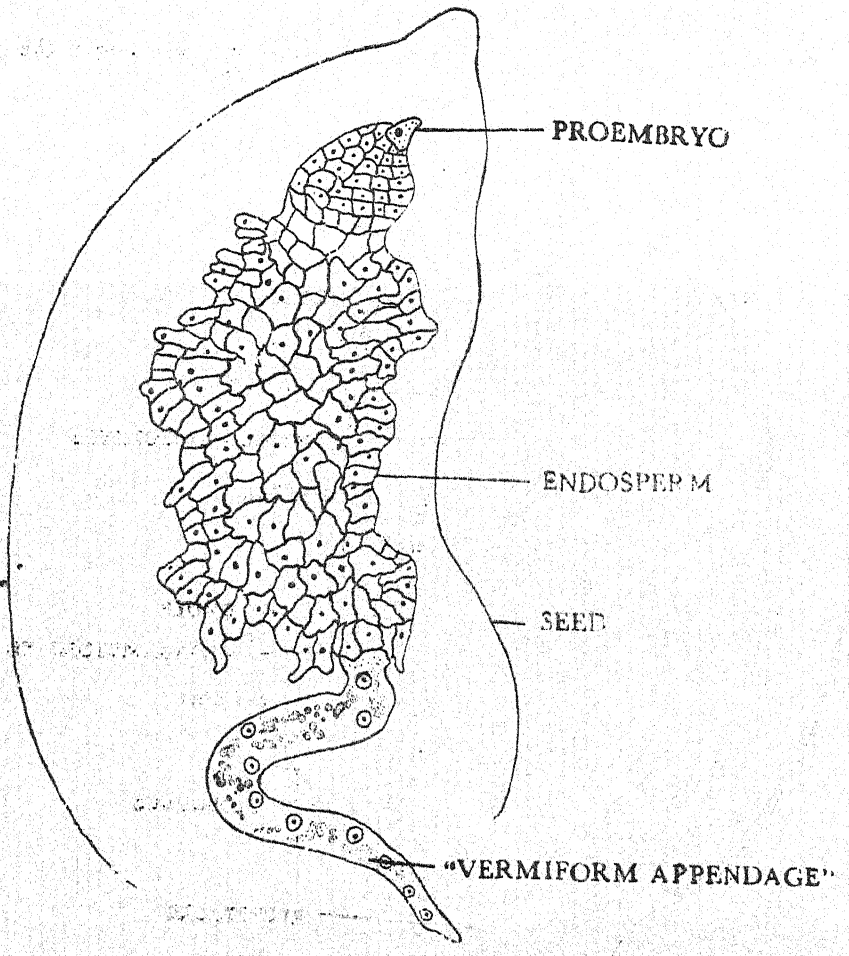


Fig. 134. L. S. of the seed of *Grevillea robusta* showing nuclear type of endosperm and a "vermiform appendage" (endosperm haustorium) formed from the lower part of the endosperm.

MICROPYLAR & CHALAZAL HAUSTORIA OF NEMOPHILA

(1) This is l. s. of the ovule of *Nemophila aurita* showing both micropylar and chalazal haustoria.

(2) The endosperm is of cellular type.

(3) A two-celled proembryo is seen at the micropylar end of the ovule.

(4) The endosperm cells, both from the micropylar end as well as the chalazal end, give out tube-like or finger-like processes.

(5) These structures can suck up food, are haustorial in nature and are called cellular endosperm haustoria.

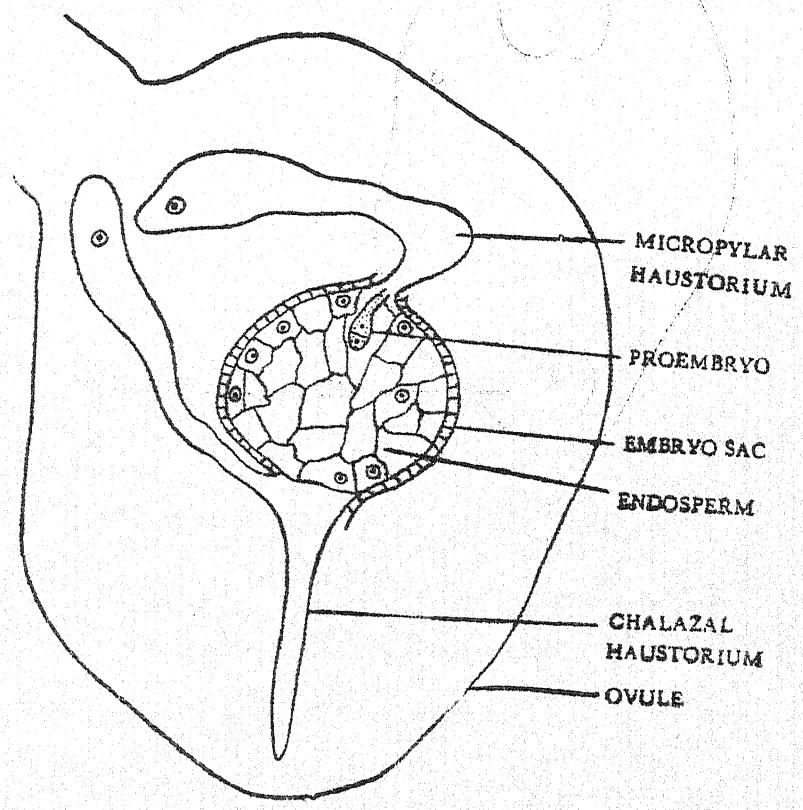


Fig. 135. L. S. of ovule of *Nemophila autria* showing both micropylar and chalazal haustoria.

Examine and sketch the permanent slides showing polyembryony.

(1) In the slide three embryos are seen, two at the micropylar end and one at the chalazal end.

(2) At the micropylar end one embryo is normal zygotic embryo but the other one is formed from the synergid cell. This is called synergid embryo.

(3) The embryo present at the chalazal end is formed from the antipodal cell and is called the antipodal embryo.

(4) Common example is *Elatostema eurhynchum.*

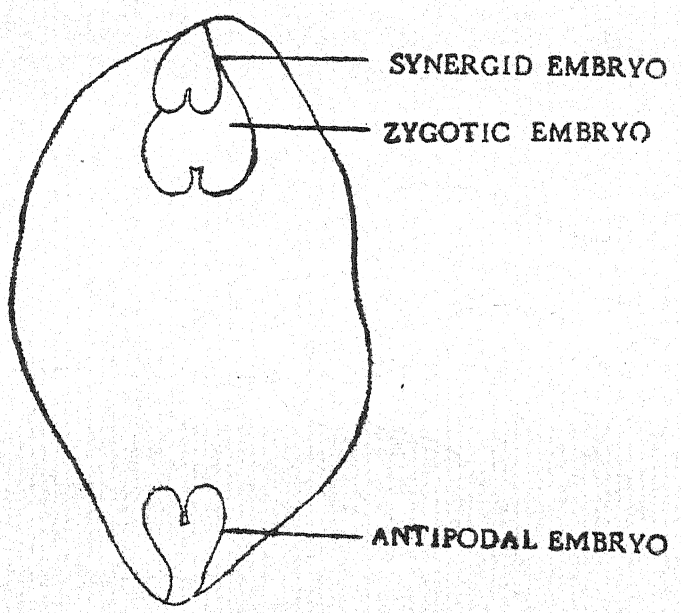


Fig. 136. Showing the zygotic, synergid and antipodal embryos in the embryo sac.

ADVENTIVE EMBRYONY IN CITRUS

(1) This is a slide showing adventive embryony or sporophytic budding in *Citrus.*

(2) Here embryos arise from the cells of the nucellus or the integument.

(3) The diploid cells of the nucellus or the integuments directly give rise to embryos with out fertilization.

(4) The nucellar and integumentary embryos push their way into the embryo sac and form true embryos.

(5) The adventive embryos are lateral in position and lack suspensor.

(6) A zygotic embryo with a suspensor is also seen.

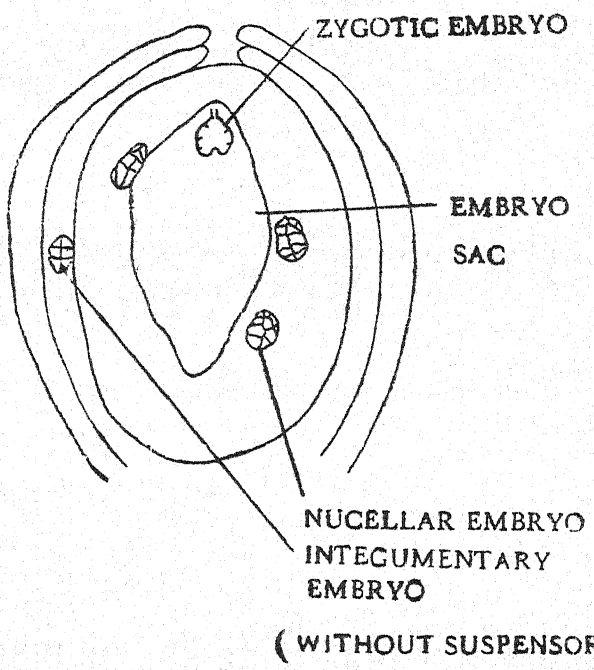


Fig. 137. Illustrating the positions of the nucellar, integumentary and zygotic embryos.

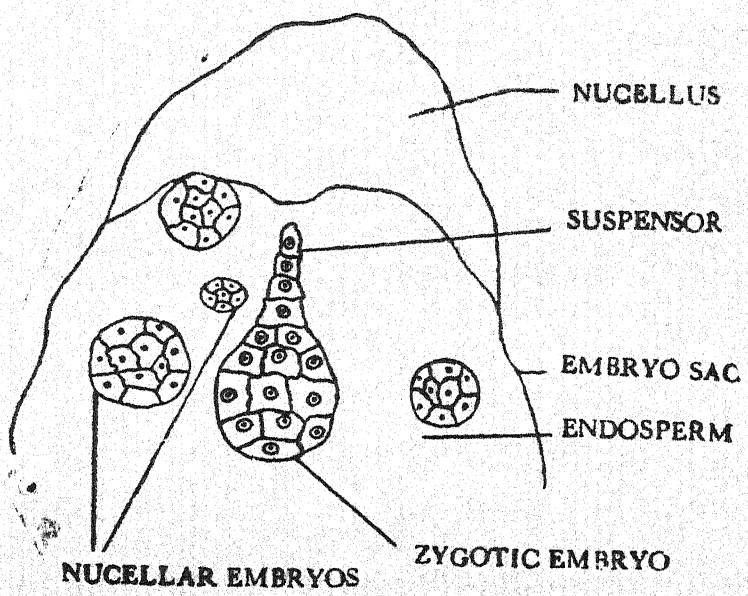


Fig. 138. A portion of the l. s. of young seed of *Citrus* showing a normal zyotic embryo with the suspensor and young nucellar embryos without the suspensor. The nucellar embryos come to lie into the embryo sac.

Examine and sketch the museum specimens of the different stages of *epigeal* and *hypogeal germination* of castor seed and maize grain.

EPIGEAL GERMINATION

(1) The seeds of castor bean (*Ricinus communis*) show epigeal germination.

(2) The cotyledons are pushed upwards due to the rapid elongation of the *hypocotyl*.

(3) Hypocotyl is the portion of the axis lying just below the cotyledons.

(4) The cotyledons come up above the ground.

(5) This type of germination is also known as *epigeous* (*epi* means 'upon' and *ge* means 'earth').

(6) Majority of the dicotyledonous seeds show this type of germination.

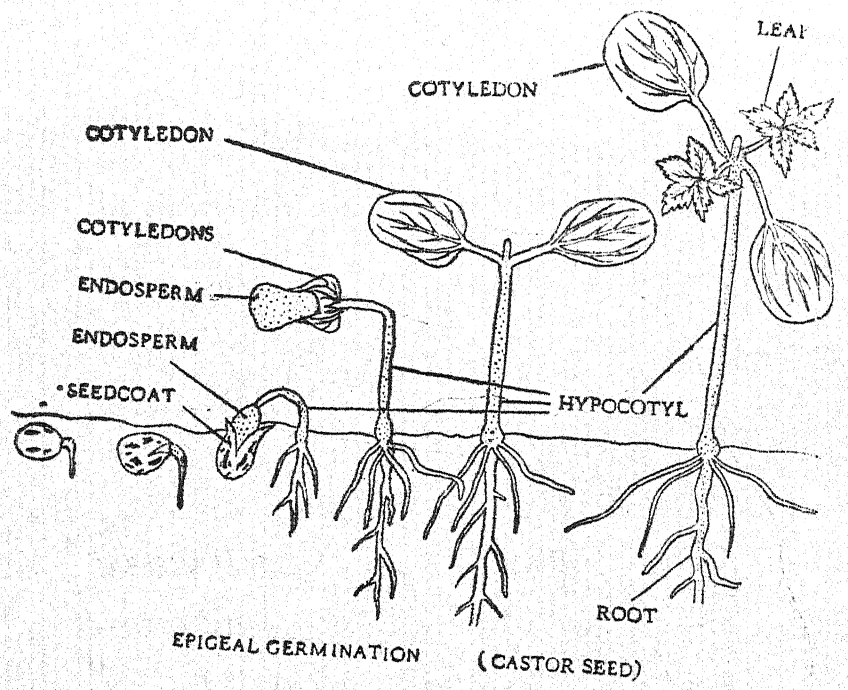


Fig. 139. Showing germination of seed and development of seedling in *Ricinus communis* (castor bean).

HYPOGEAL GERMINATION

(1) The maize grains (*Zea mays*) are seen here in various stages of germination.

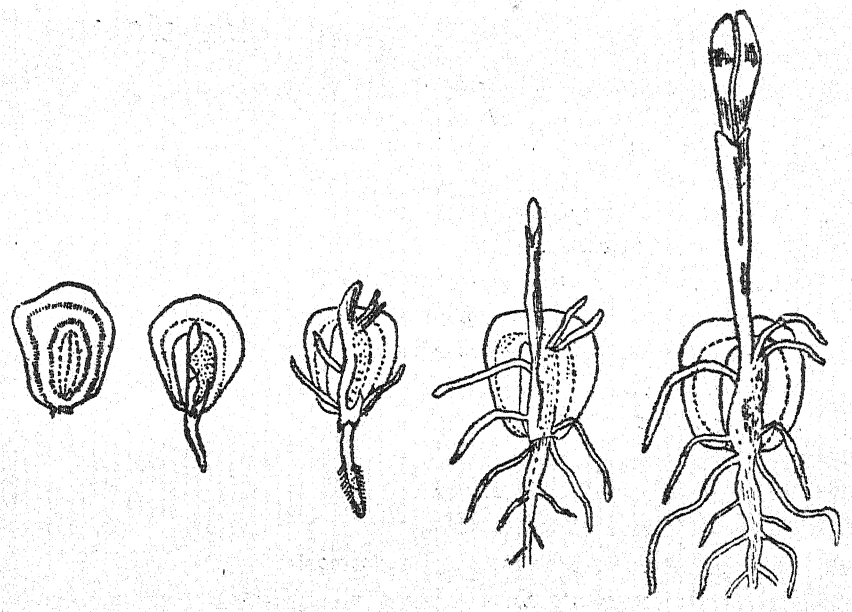
(2) The type of germination is *hypogeal*.

(3) The cotyledons and the endosperm remain burried in the soil.

(4) This type of germination is also known as *hypogeous* (*hypo* means 'below' and *ge* means 'earth').

(5) The seeds are mostly endospermic or albuminous.

(6) Majority of monocotyledonous seeds and some dicotyledonous seeds show this type of germination.



HYPOGEAL GERMINATION (MAIZE GRAIN)

Fig. 140. Showing germination of seed and development of seedling in *Zea mays* (corn or maize).

CHAPTER 4

Physiology

Perform the following experiments. Note down the requirements separately for each experiment. Write down the procedure, observations and the conclusions you draw for each experiment. Note the precautions wherever necessary.

1. Preparation of *suspensoid* solution.
2. Preparation of *emulsoid* solution.
3. Demonstration of *Brownian movement.*
4. Demonstration of the *Streaming movement* of proeoplasm
5. Testing the presence of *glucose* by the following two tests :

(i) *Trommer's Test*

(ii) *Fehling's Test*

6. Testing the presence of *starch.*
7. Testing the presence of *protein.*
8. Demonstration of *exosmosis* and *endosmosis.*
9. Demonstration of *starch* formation in *chloroplasts* by using some *alga* or *moss leaf.*
10. To assign the given *starch suspensions* to the plants to which they belong.
11. Comparison of the *osmotic concentrations* of the given solutions in relation to the *cell sap* by the *plasmolytic method.*
12. Comparision of the *osmotic concentrations* of the given solutions in relation to the *cell sap* by the *turgidity method.*
13. Comparision of the rates of the *tranpiration* of the two surfaces (doral and ventral) of a leaf by *cobalt chloride paper; method.*
14. To fit up an apparatus to demonstrate that *R. Q. is unity.*

EXPERIMENT 1

Object--To prepare *suspensoid* solution.

Requirements—33% Ferric chloride solution, distilled water, two test tubes, a spirit lamp and two test tube holders.

Procedure—Take a few c.c. of distilled water in a test tube and boil it. Take a few c.c. of 33% Ferric chloride solution in another test tube and pour it into the boiling water.

Observation—The colour changes to deep brown-red.

Conclusion—The change in the colour is due to the formation of a colloidal Ferric hydroxide solution, a suspensoid solution.

Conclusion—The starch settles down in the form of a precipitate.

EXPERIMENT 10

Object—To test the presence of starch (microchemical test).

Requirements—Soaked pea seeds, Iodine solution, microscope, coverslip and slide.

Procedure—Cut a thin section of the soaked pea seed. Stain your section in Iodine solution and observe it under the microscope.

Observation - The section becomes blue coloured.

Conclusion—The pea seeds contain starch grains which h[illegible] do to the Iodine solution.

EXPERIMENT 11

Object—To test the presence of *protein* in *Caloropis procera* : Family- Asclepiadaceae). a microscope slide and a coverslip.

Procedure—Take a drop of latex from *Caloropis* and make a thin coating by smearing on the slide. Mount it and observe the movement of the particles under the high power of the microscope.

Observation—Minute colloidal particles are seen moving in a *zigzag* manner.

Conclusion—This is the *Brownian movement* as this type of movement of the particles was first observed by a botanist Robert Brown in 1928. According to Perrin it is due to the bombardment of the colloidal particles by the molecules of the solvent.

Precaution—Delay in mounting results in drying up of the liquid.

EXPERIMENT 4

Object—To demonstrate *streaming movement* of protoplasm.

Requirements—Young leaves of *Hydrilla* plant (Hydrocharidaceae), microscope, slide and coverslip.

Procedure—Mount a young leaf of *Hydrilla* in water on a slide and observe under the high power of the microscope.

Observation—The chloroplasts are seen moving in a stream in clock-wise manner. The chloroplasts move due to the streaming movement of the protoplasm.

Precaution—(i) The leaves of *Hydrilla* are taken from the apical portion of the stem.

(ii) Fresh leaves are used in this experiment because the movement stops after some time.

EXPERIMENT 5

Object.—To test the presence of glucose by *Fehling's test.*

Requirements.—Fehling's solutions A & B, test tubes, glucose solution and spirit lamp.

Procedure.—Take a few c. c. of freshly prepared Fehling's solutions A & B in a test tube and boil it. To this boiled solution add glucose solution in equal quantity and again boil it.

CHAPTER 4

Physiology

Perform the following experiments. Note down the requirements ately for each experiment. Write down the procedure, observations equal qua nclusions you draw for each experiment. Note the precau tions
Observat sary.

Conclusion—Th f *suspensoid* solution.
sation product of sugar.
ulsoid solution.
EP ian movemer

Observation—To test the presence of glucose by *Trommer's test.*

Requirements—1% Copper sulphate solution, 5% caustic soda solution, glucose solution, test tubes, test tube holder and a spirit lamp.

Procedure & Observation—Take a few drops of 1% copper sulphate solution in a test tube. Take a few c. c. of 5% caustic soda solution in another test tube. Add the copper sulphate solution in the caustic soda solution. A blue coloured precipitate is formed. Now add 2 or 3 c. c. of glucose solution to it. The precipitate disappears. Boil it till a brick-red precipitate appears.

Conclusion—The blue coloured precipitate appears due to the formation of cupric hydroxide. The precipitate disappears after adding glucose solution but again a brick-red precipitate appears due to the formation of cuprous oxide.

EXPERIMENT 8

Object—To test the presence of *starch.*

Requirements—Starch solution, Iodine solution, test tube, test tube holder and a spirit lamp.

Procedure—Take a few c. c. of starch solution in a test tube and add a few drops of Iodine solution. The colour of the solution becomes blue. Heat this solution and then cool it.

Observation—On heating the blue colour disappears but reappears on cooling.

Conclusion—Iodine solution gives blue colour to the starch grains and the colour reappears on cooling.

EXPERIMENT 9

Object—To test the presence of *starch.*

Requirements—Starch solution, alcohol and a test tube.

Procedure—Take a few c. c. of starch solution in a test tube and add to it alcohol in equal quantity.

Observation—A precipitate is formed.

Conclusion—The starch settles down in the form of a precipitate.

EXPERIMENT 10

Object—To test the presence of starch (microchemical test).

Requirements—Soaked pea seeds, Iodine solution, microscope, coverslip and slide.

Procedure—Cut a thin section of the soaked pea seed. Stain your section in Iodine solution and observe it under the microscope.

Observation - The section becomes blue coloured.

Conclusion—The pea seeds contain starch grains which become blue do to the Iodine solution.

EXPERIMENT 11

Object—To test the presence of *protein* by *Millon's test.*

Requirements—Protein solution, Millon's reagent, test tube, test tube holder and a spirit lamp.

Procedure—Take a few c. c. of protein solution in a test tube and add to it Millon's reagent about half its volume. Warm it and observe the changes before and after warming.

Observation—Before warming a white precipitate is formed due to the reaction of Mercuric nitrate on the proteins. On warming the precipitate turns brick-red in colour or the precipitate disappears leaving red solution.

Conclusion—The white precipitate apprars due to the reaction of Mercuric nitrate (present in the Millon's reagent) on proteins confiring the presence of protein.

EXPERIMENT 12

Object—To test the presence of protein.

Requirements—Protein solution, 40% sodium hydroxide solution, 1% copper sulphate solution and test tube.

Procedure—Take a few c. c. of protein solution in a test tube. To this solution add one c. c. of 40% sodium hydroxide solution and also one drop of the 1% copper sulphate solution and observe.

Observation—The colour of the solution becomes violet or pink.

Conclusion—The change in colour shows the presence of protein.

EXPERIMENT 13

Object—To demonstrate the phenomenon of *exosmosis.*

Requirements—A few grape berries (fruits), strong salt solution and 2 petridishes.

Procedure—Put a few grape berries in a petridish containing strong salt solution and keep a few berries in a dry petridish. Observe both the petridishes after some time.

Observation—After some time the grape berries kept in the strong salt solution get reduced in size i. e. they show shrinkage and the grape berries kept in the other petridish remain as such.

Conclusion—The shrinkage in the size of the berries is due to the fact that water (solvent) comes out (in the out side medium of the salt solution) from the cell sap. This movement of the cell sap molecules is known as *exosmosis*.

EXPERIMENT 14

Object—To demonstrate the phenomenon of *endosmosis*.

Requirements—Weak salt solution, water, dry raisins and petridishes.

Procedure—Put some dry raisins in weak salt solution or pure water in a petridish. Leave it for some time and observe.

Observation—After some time the raisins swell up and increase in size.

Conclusion—Water from the outside medium moves inside the cell sap of the raisins as concentration of water molecules is greater in the outside medium than the concentration of water inside the cell sap.

EXPERIMENT 15

Object—To demonstrate that starch formation takas place in the chloroplasts only (by using some alga or moss leaf).

Requirements—Chloral hydrate iodine solution, green alga or moss leaf, slide, coverslip and a microscope.

Procedure—Prepare an unstained mount of the green alga or the moss leaf. Treat a few filaments of the green alga or moss leaf with chloral hydrate iodine solution and mount it on another slide. Observe it under the microscope and compare it with that of the other slide.

Observation—In the first slide the position of the chloroplasts is well marked but in the second slide blue dots are seen.

Conclusion—The blue colour shows the presence of starch.

EXPERIMENT 16

Object—To assign the given starch suspensions to the plants to which they belong.

Requirements—Starch suspensions of the following plants :

(i) Potato (*Solanum tuberosum*) tuber

(ii) Wheat (*Triticum aestivum*) grains

(iii) Pea (*Pisum sativum*) seeds

(iv) Banana (*Musa paradisiaca*) flesh

(v) Sweet potato (*Ipomoea batatus*) root

(vi) Rice (*Oryza sativa*) grains

(vii) Maize (*Zea mays*) grains

(viii) Gram (*Cicer aeriatinum*) seeds

(ix) Oat (*Avena sativa*) grains

Slides, coverslips, Iodine solution and a microscope.

Procedure—Treat all the starch suspensions separately with Iodine solution and prepare separate mounts. Examine and sketch the different starch grains. Note the structure and position of the *hilum* and lamellations.

Observation—(i) Every starch grain has a shiny refractive point known as the *hilum*, which is the starting point.

(ii) Starchy materials are deposited in layers around the hilum. These starchy depositions give the grain a distinct stratified appearance. These are known as *lines of stratifications.*

(iii) A starch grain having one *hilum* with a number of stratifications around it is known as a *simple* starch grain.

(iv) In some cases the starch grains show more than one hilum. Here more than one grain are appressed together making it *compound* grain.

(v) In some cases starch grains with two hila with their lines of stratifications are seen. These are bounded by common lines of stratifications. These are *semicompound* starch grains.

Conclusion :

The structure of the starch grains from the different plants are as below :

(i) **Potato**—The starch grains are oval and the hilum is located at one end of the grain. The deposition of layers are unequal. These are called concentric grains. *Semicompound* starch grains with two hila are also seen.

(ii) **Rice**—Starch grains are small, polygonal and hilum is in the centre. Stratifications are well marked surrounding the hilum. Compound grains are also seen.

(iii) **Wheat**—Starch grains small, circular, flattened, hilum central and stratifications not well marked.

(iv) **Pea and gram**—In the starch grains of the pulses the hilum is present more or less in the centre due to uniform deposition of the layers. Semicompound starch grains are also seen.

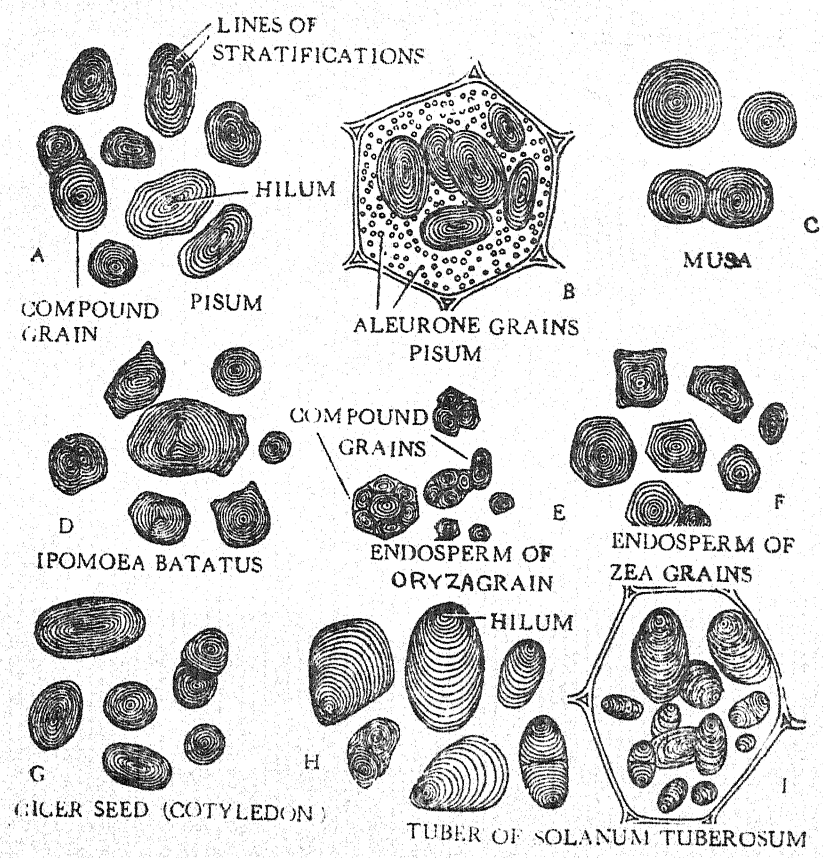


Fig. 141. Showing *simple, semicompound* and *compound* starch grains. A & B (Pea), C (Banana), D (Sweet potato), E (Rice), F (Maize), G (Gram) and H & I (Potato tuber).

(v) **Maiz**—The starch grains are of various shapes and sizes. Hilum is situated in the centre and is surrounded by stratifications.

(vi) **Oat**—Starch grains are compound, individual units polygonal, stratifications not clear.

(vii) **Banana**—Starch grains are circular, large sized, hilum situated in the centre, stratifications surround the hilum. Semicompound starch grains are also seen.

(viii) **Sweet potato**—The starch grains are of various shapes and sizes. Hilum is located in the centre of the grain surrounded by stratifications. Semicompound grains are also seen.

EXPERIMENT 17

Object—To compare the *osmotic concentrations* of the two solutions in relation to the cell sap by *plasmolytic method*.

Botany Practical

Requirements—A leaf of *Rhoeo discolor*, coverslips, slides, microscope, salt solutions A & B of different concentrations, and watch glasses.

Procedure—Peel off the lower epidermis (coloured) of the leaf of *Rhoeo discolor* and examine under the microscope. Now take two equal pieces of the epidermis and put them in separate watch glasses containing salt solutions A & B. After some time observe the two pieces under the microscope and note the result.

Observation—(i) The cells of the epidermis (before keeping in the salt solutions) are completely filled with redish cell sap.

(ii) In the hypotonic (slightly concentrated) salt solution A, the cell contents withdraw slightly from the cell wall. Space is created in between the cell wall and the cell sap.

(iii) In the hypertonic (strong) salt solution B, the cell contents move away from the cell wall and larger space is created in between the cell wall and the cell sap. Ultimately they shrink into a small ball-like structures.

Conclusion—(i) This is the normal condition of the cell where the cell sap presses the protoplasm against the cell wall. Thus the cell is seen in slightly inflated condition. The cell is in deplasmolysed state.

(ii) The water from the cell sap moves towards the outside medium. The vacuole becomes smaller. The space in between the cell wall and the contents indicates the begining of the plasmolysis. This is also known as *incipient plasmolysis*.

(iii) The shrinkage of the cell contents into a ball-like structure and the widened space indicates *complete plasmolysis*.

[Note : This experiment can also be demonstrated with the help of leaves of *Hydrilla or Zebrina*, staminal hairs of *Tradescantia* or petals of *Luffa* or *Thunbergia*.]

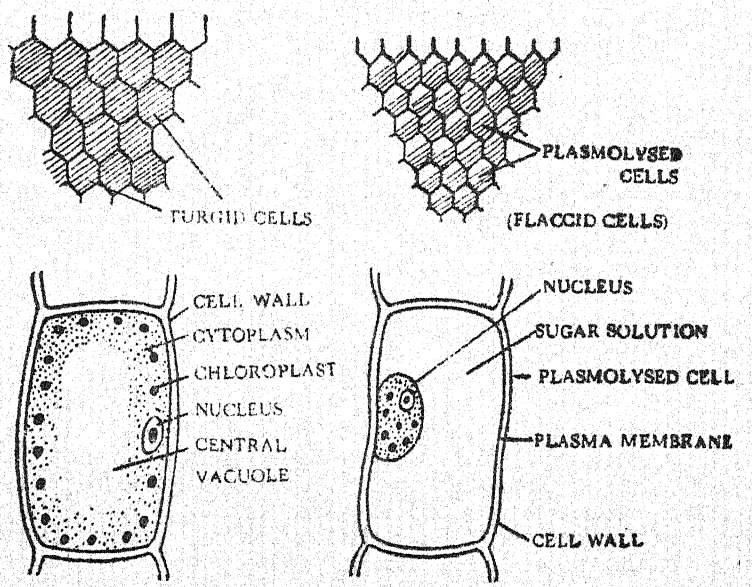


Fig. 142. Showing normal *deplasmolysed* and *plasmolysed* cells.

EXPERIMENT 18

Object—To compare the osmotic concentrations of the two solutions in relation to the cell sap by *turgidity method*.

Requirements—*Amarnathus* stem, salt solution A & B, water, and three watch glasses.

Procedure—Take two equal pieces of the stem of *Amarnathus* and cut them longitudinally. Select three equal pieces. Now put these pieces in the three watch glasses containing water, weak salt solution A and strong salt solution B. Observe these pieces after some time.

Observation—(i) The picees put in the water and the weak salt solution A bend towards the epidermis.

(ii) The piece kept in the strong salt solution B, bends towards the pith or the cut surface.

Conclusion—(i) The movement of the water molecules takes place from the outside medium into the cell sap. The cells become *turgid* and get streched so much so that bending or concavity appears towards epidermis and the cut surface becomes convex. This is seen in the weak hypotonic salt salution A.

(ii) The water molecules move from the cell sap into the outside medium. The cells towards the cut surface lose water and become *flaccid*. The cut surface thus becomes concave and the other surface shows convexity. This is seen in the hypertonic (strong) salt solution B.

EXPERIMENT 19

Object—To compare the rates of *transpiration* from the dorsal and the ventral surfaces of a dorsiventral leaf by cobalt chloride paper method.

Requirements—Dried cobalt chloride papers, slides, thread, a fresh leaf of *Nerium* or *Mangifera*.

Procedure—Take a *Nerium* leaf and place dried cobalt chloride papers on both the surfaces. Put it inbetween two slides and tie down with the help of the thread. After some time observe the change in colour of the cobalt chloride papers.

Observation—After some time the dried cobalt chloride paper changes its blue colour to red. The other paper incontact with the upper surface retains its blue colour.

Conclusion—The lower surface of the leaf loses water as the rate of transpiration is rapid due to the presence of the stomata. The moisture (water) changes the blue colour of the cobalt chloride paper to red. Thus the rate of stomatal transpiration (from the lower surface of the leaf) is rapid than the cuticular transpiration from the upper surface of the leaf because of the absence of the stomata.

Precaution—The cobalt chloride paper should be dry and be kept in a *desiccator* before use.

EXPERIMENT 20

Object—To fit up an apparatus to demonstrate that *R. Q. is unity.*

Requirements—Germinating wheat seeds, cotton, saline water, test tube, petridish, and glass marking pencil.

Procedure—Take a few germinating wheat grains (seeds) in a test tube and plug it with cotton. Fill the tube with saline water. keep it inverted in a petridish containing saline water. Now mark the level of saline water in the test tube with the help of a glass marking pencil. Leave it as such for some time and observe the change in the level of the saline water in the test tube.

Observation—There is no change in the level of the solution in the test tube.

Conclusion—There is no change in the level of the solution because in case of carbohydrates R. Q. is unity. This can be explained as follows :

(i) R. Q. or *Respiratory Quotient* is the ratio between the volume of carbondioxide given out and the volume of oxygen absorbed. The R.Q. can be equal to unity, less than unity or more than unity.

(ii) In this case the respiratory substrate is carbohydrate (wheat).

(iii) When carbohydrates or hexose sugars are consumed in respiration, the value of R. Q. is unity.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 673 \text{ kg. cal.}$$

$$\text{R. Q.} = \frac{CO_2 \text{ evolved}}{O_2 \text{ absorbed}} = \frac{6}{6} = 1$$

EXPERIMENT 21

Object—To demonstrate the phenomenon of *osmosis* by *Potato osmoscope.*

Requirements—Potato tuber, sugar solution, beaker, water, cork, stand and glass marking pencil.

Procedure—Make a cavity in the potato tuber and fill it with the sugar solution. Take a cork with a hole in the centre and fit in the cavity. Insert a glass tube in the cork. One end of the tube should dip in the sugar solution. Keep it in a beaker containing water with the help of a stand as shown in the figure. Mark the initial level of the sugar solution in the tube with the help of the glass marking pencil. Keep it for some time and then observe the level of the sugar solution in the tube.

Observation—The level of the sugar solution in the tube rises.

Conclusion—The potato tuber acts as a semipermeable membrane. The water molecules move from out side into the cavity of the potato tuber containing sugar solution because of the higher concentration of sugar due to *osmosis.*

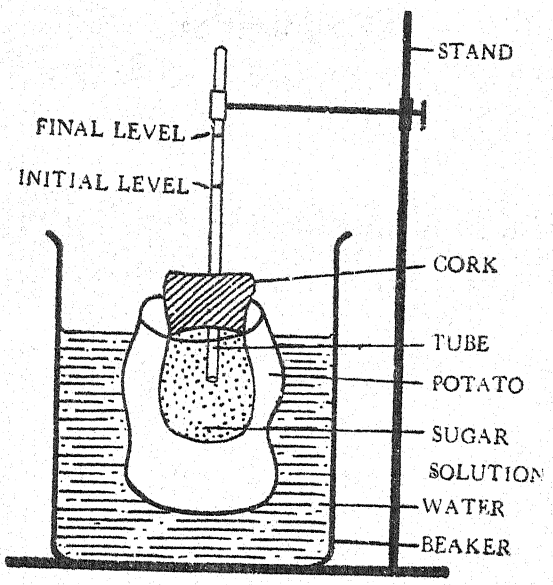


Fig. 143. Showing *osmosis* by Potato osmoscope.

EXPERIMENT 22

Object—To demonstrate the phenomenon of *osmosis* by egg membrane.

Requirements—An egg, sharp needle, dilute hydrochloric acid solution, beaker, water, stand, glass marking pencil and funnel.

Procedure—Make a hole in the egg and empty it by throwing off the contents. Keep the shell in dilute hydrochoric acid solution till calcium carbonate gets dissolved and only the egg membrane remains.

Attach the egg membrane to a funnel and pour sugar solution inside the sac of the egg membrane. Keep it in a beaker containing water and fit up the apparatus as shown in the figure with the help of a stand. Mark the initial level of the sugar solution in the funnel with the help of the glass marking pencil. Leave it for some time and then observe the change of the level of the solution in the funnel.

Observation—After some time the level of the sugar solution in the funnel rises.

Conclusion—The water from the beaker moves inside the egg membrane due to *osmosis*.

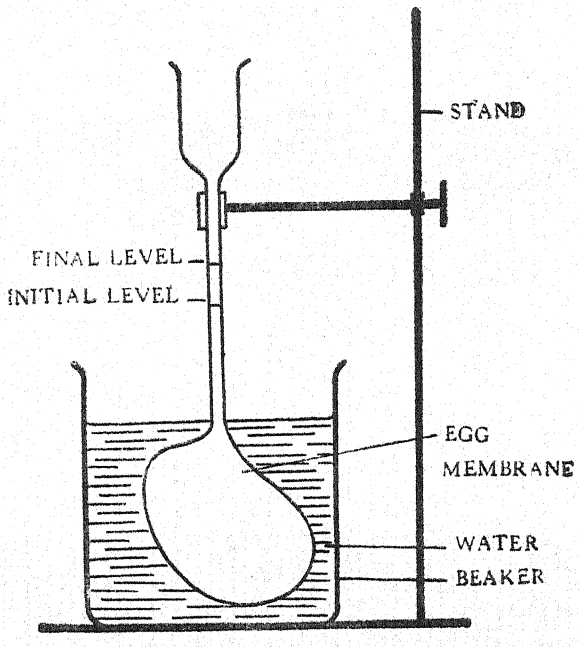


Fig. 144. Showing *osmosis* by egg membrane.

EXPERIMENT 23

Object—To measure the osmotic pressure of a solution.

Requirements—Sugar solution, goat's bladder, thread, wide tube with cork, narrow tube with cork, beaker, water, stands, manometer and mercury.

Procedure—Fit the apparatus as shown in the figure and note the level of the mercury in the manometer. Observe the level of the mercury in the manometer after some time.

Observation—The level of the mercury rises in the manometer (free end).

Conclusion—Goat's bladder acts as a semipermeable membrane. Water molecules move from the beaker and enter into the sugar solution through the goat's bladder. Due to the osmotic pressure of the solution, the level of mercury rises in the free end of the manometer.

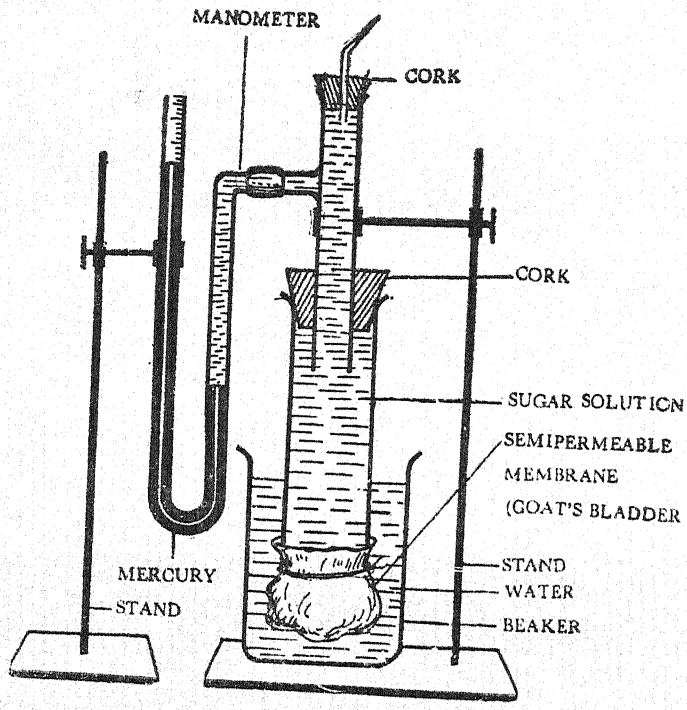


Fig. 145. Showing *osmosis* by goat's bladder.

EXPERIMENT 24

Object—To demonstrate the development of *imbibitional pressure* during imbibition by germinating seeds.

Requirements—Dry gram seeds, bottle, water, cork for the tube with a hole in it, a disc fitted in the bottle, a pointer attached to the disc, a stand with a scale attached to it.

Procedure—Take a few gram seeds and put it in the bottle containing water. Fit the disc over the seeds. Adjust the pointer over zero mark on the scale and observe after a few hours.

Observation—The pointer moves down. The seeds are swollen and the disc moves a little upwards.

Sushil Kumar Purwar '87-88.

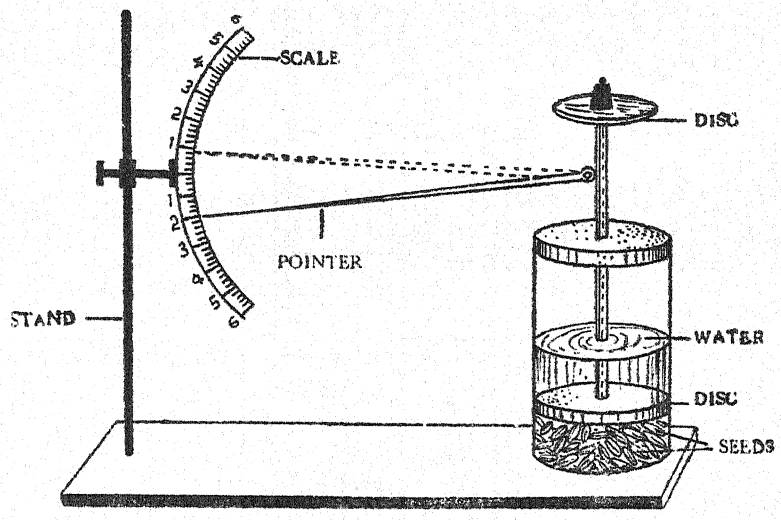


Fig. 146. Showing the apparatus for demonstration of the development of the imbibitional pressure and its measurement.

Conclusion—The gram seeds absorb water due to imbibition and swell up. The fact is that the hydrophilic colloids of the gram seeds absorb water. The increase in the size of the seeds pushes the disc upwards. This is due to the development of a pressure. This pressure is responsible for the movement of the pointer downwards. The displacement of the pointer records the *imbibitional pressure* developed during the experiment.

Precaution—(i) The seeds taken for this experiment should be completely dry.

(ii) The disc must touch the seeds.

EXPERIMENT 25

Object—To demonstrate and measure root pressure.

Requirements—A well-watered potted plant, rubber tube, manometer, mercury, stand, water, glass marking pencil and razor.

Procedure—Cut the shoot of the plant a few inches above the soil level and connect the cut end to the manometer with the help of a rubber tube. Fill the tube above the cut end with water and the bent tube of the manometer with mercury. Mark the initial level of the mercury. Keep this experiment in a humid chamber for a few hours and then note the change in the level of the mercury.

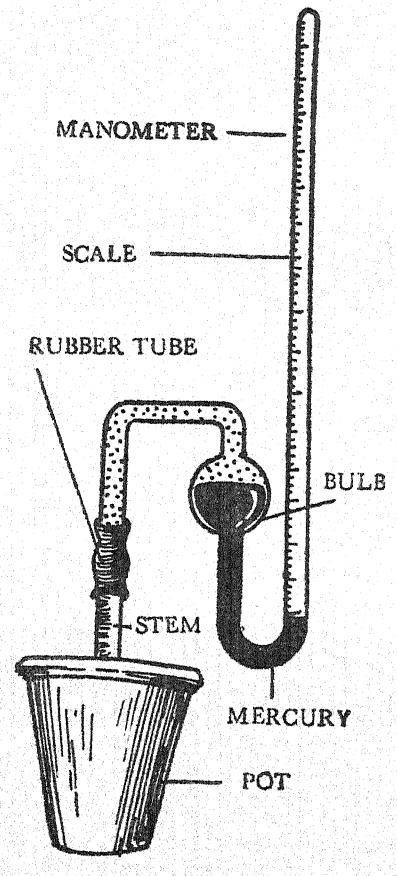


Fig. 147. Showing the development of root pressure and its measurement with the help of the manometer.

Observation—The level of mercury rises in the manometer but goes down in the bulb.

Conclusion—The water comes out from the cut end of the stump in the tube. This water is being forced from the root into the stem. This is due to the development of the root pressure. The water pushes the level of mercury in the bulb to move downwards but the level of mercury rises in the manometer due to root pressure. The root pressure is measured with the help of the manometer.

EXPERIMENT 26

Object—To demonstrate the development of root pressure.

Requirements—A well-watered potted plant, rubber tube, glass tube, stand, razor, oil, glass marking pencil and water.

Procedure—Cut the shoot of the potted plant a few centimeters above the soil level. Connect the cut end of the stem to a glass tube with the help of the rubber tube. Fill the glass tube with water. Put a drop of

oil on the surface of the water and mark the level of water in the glass tube with the help of the glass marking pencil. Leave the experiment as such in a humid chamber for a few hours and note the change in the level.

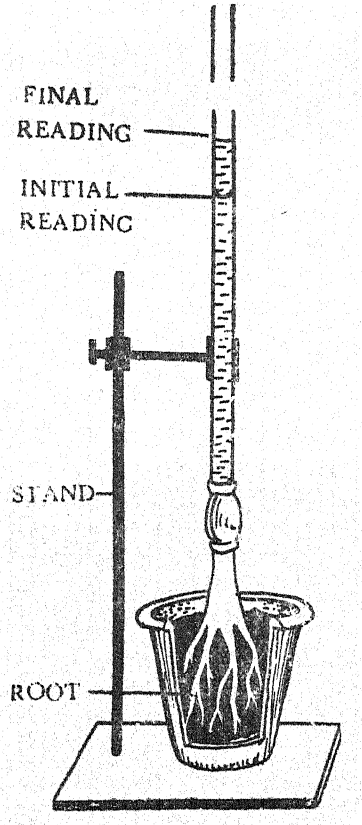


Fig. 148. Showing the apparatus for the demonstration of root pressure.

Observation—The level of the water in the tube rises.

Conclusion—The rise of water level is due to the water coming out through the cut end of the stem in the tube due to root pressure.

EXPERIMENT 27

Object—To demonstrate ascent of sap.

Requirements—Beaker, coloured solution (red), stand, freshly dug out root plant with white petal flowers.

Procedure—Take the red coloured solution in the beaker and fix the plant with the help of the stand with its roots dipped in the coloured solution. Keep as such for some time and then observe the change in the colour of the white petals of the flowers.

Observation.—After some time the white petals become red tinged. The veins of the petals become red coloured.

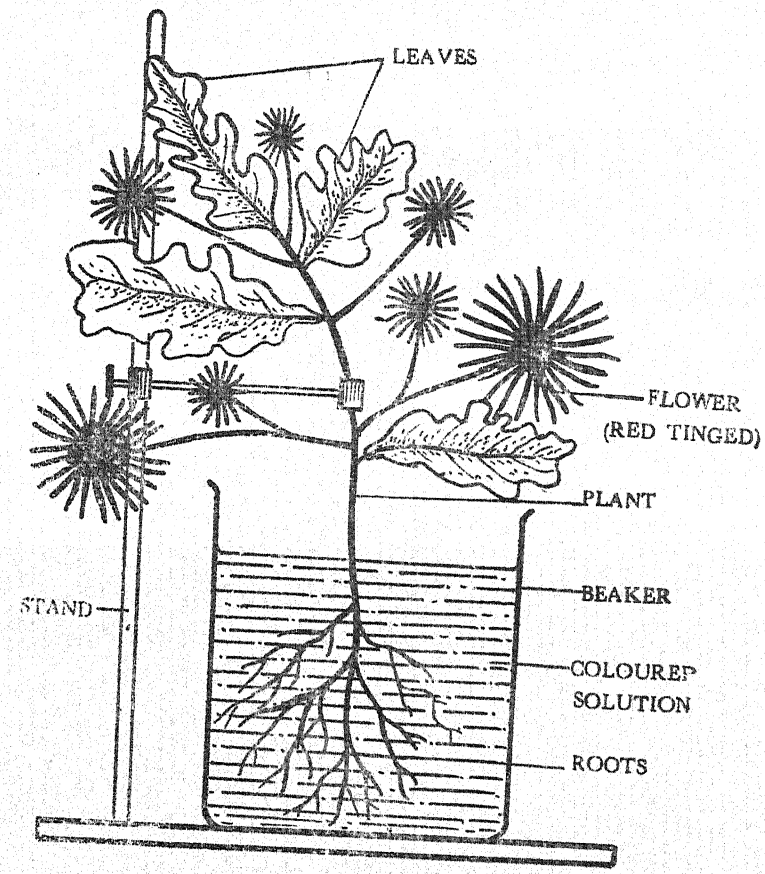


Fig 149. Showing *ascent of sap.*

Conclusion.—The solution is absorbed by the roots and is conducted through the stem to the petals. The veins of the petals become red. The ascent of sap takes place through xylem which is marked in the petals.

EXPERIMENT 28

Object—To demonstrate ascent of sap through xylem after removing phloem – *ringing experiment.*

Requirements—Beaker, water, wax, twigs, razor and stand.

Procedure—Take a plant twig and remove the bark (including phloem) from a portion of the stem without causing any injury to the xylem. Take another twig and remove the xylem without injuring the phloem and the bark. This is known as ringing.

[Note—The xylem, phloem or the cells of the cortex can be blocked by the application of wax or vaseline to these tissues.]

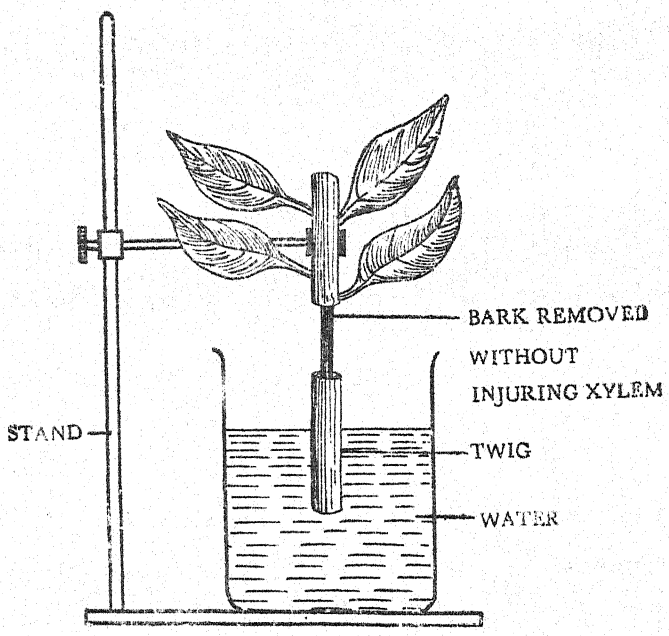


Fig. 150. Ringing experiment to show that ascent of sap (water) takes place through xylem. The bark is removed without injuring xylem.

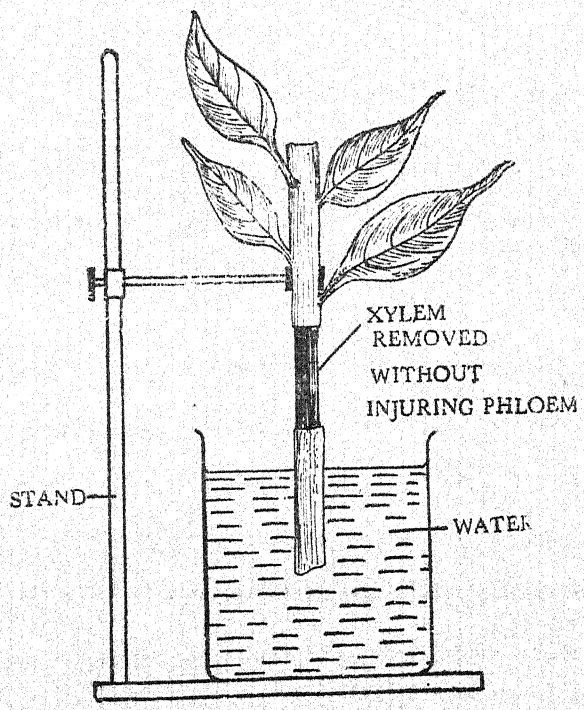


Fig. 151. Showing ringing experiment. Xylem is removed without injuring phloem.

Keep the lower cut ends of the twigs dipped in water and observe the change in the condition of the leaves of the two twigs.

Observation—The leaves of the twig show no change where phloem and bark is removed but the leaves of the other twig show wilting.

Conclusion—This shows that ascent of sap (water) takes place through the xylem. The second case shows wilting because xylem is removed.

Precaution—Ringing or the removal of the tissues should always be done while the twigs are under water.

EXPERIMENT 29

Object—To demonstrate *transpiration* in plants by *Student's potometer.*

Requirements—Student's potometer, capillary tube, beaker, water, scale or graduated card, wax, stand and twig.

Procedure—The potometer is filled with water. The stem of the twig is inserted through the hole in the cork in the side limb. Plug the two ends of the potometer with corks and connect it with the capillary tube. The lower end of the capillary should be dipped in water. Introduce an air-bubble in the capillary tube and mark its position. Make the apparatus air-tight with the help of the wax. After some time observe the movement of the bubble.

Observation—The air bubble moves upwards.

Conclusion—The movement of the air bubble upwards in the capillary tube shows that water is transpired through the leaves. To compensate this loss of water the water molecules of the capillary tube move to the leaves and with it also the air bubble. The loss of water is compensated from the lower vessel.

Precaution :

(i) The apparatus should be air-tight.

(ii) The twig should be cut while its lower end is under water.

(iii) Lower end of the capillary tube should be dipped in water.

(iv) The whole apparatus is kept in sun light.

EXPERIMENT 30

Object—To demonstrate *transpiration* by *Ganong's potometer.*

Requirements—Ganong's potometer, cork, wax, twig, beaker, water etc.

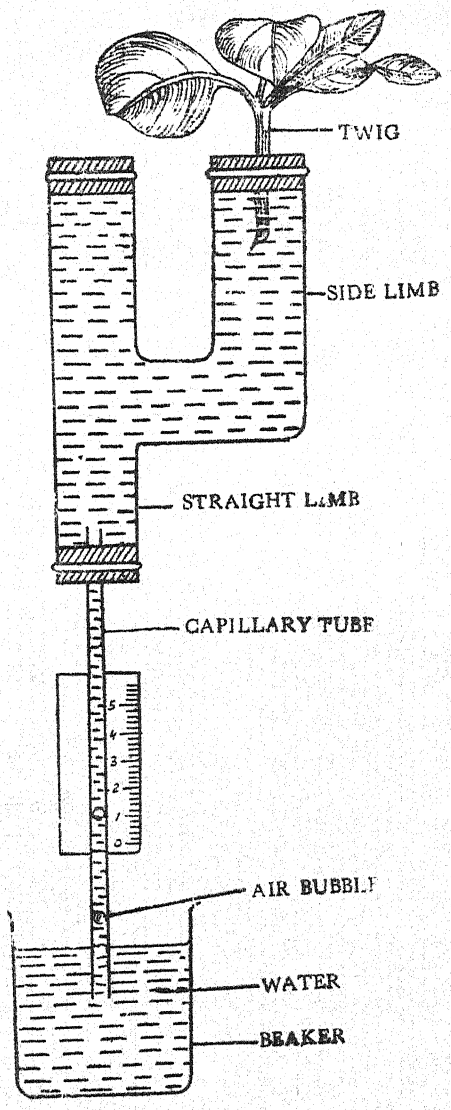


Fig. 152. Showing Student's potometer for demonstration of transpiration.

Procedure—The apparatus is fitted as shown in the figure. Introduce an air-bubble in the graduated capillary side tube and mark it. Observe the movement of the air-bubble after some time.

Observation—The air-bubble has moved towards the left side. The time and distance covered by the bubble is noted.

Conclusion—To compensate the loss of water of the mesophyll cells of the leaves, water moves from the straight tube to the leaves carrying with it the air bubble. The loss of water is ultimately compensated from the water of the beaker.

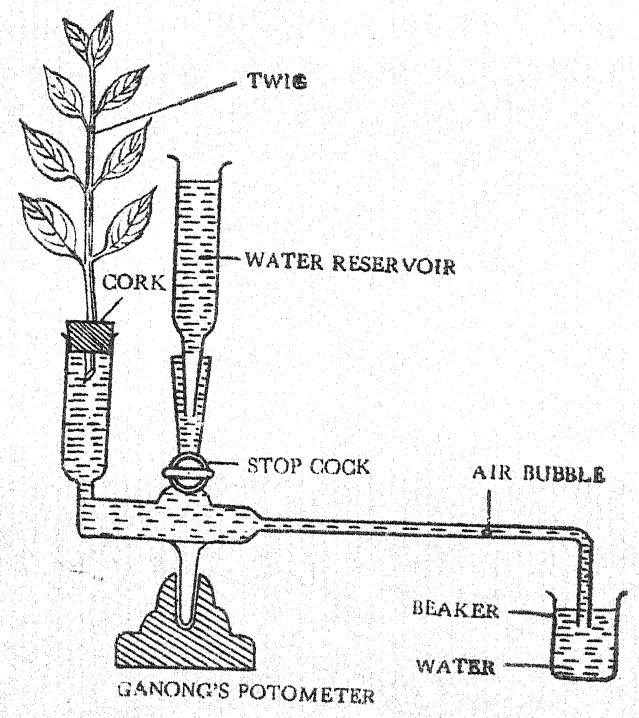


Fig. 153. Showing measurement of the rate of transpiration by Ganong's potometer.

Precaution

(i) The apparatus should be air-tight with the help of wax.

(ii) The twig should be cut while its lower part is kept under water.

(iii) The apparatus is kept in light.

EXPERIMENT 31

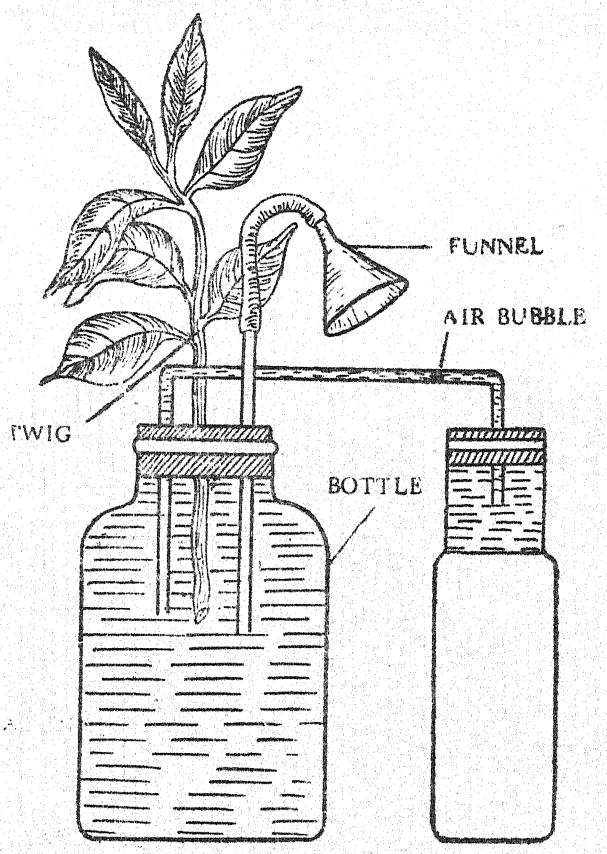
Object—To measure the rate of *transpiration* by *Farmer's potometer.*

Requirements.—Farmer's potometer, twig, cork, water, funnel, watch, rubber tube, glass tube, wax etc.

Procedure.—Fit the apparatus as shown in the figure. Make the apparatus air-tight with the help of the wax. The cut end of the twig should be dipped in water. Introduce an air-bubble in the graduated side tube. Keep the apparatus in light for some time and record the movement of the air-bubble. The funnel serves as a reservoir.

Observation—The air-bubble moves towards the left side. In a certain time the distance moved by the air-bubble is record.

Conclusion—The movement of the air-bubble takes place due to the loss of water by the leaves in transpiration. To compensate this loss of water, water from the beaker moves in the side tube. The rate of transpiration is determined by the movement of the air-bubble and the time taken.



FARMER'S POTOMETER

Fig 154. Showing Farmer's potometer.

Precaution—(i) The apparatus should be air-tight. (ii) The twig should be cut while its lower part is kept under water. (iii) The end of the capillary tube should be dipped in water. (iv) The apparatus should be kept in light.

EXPERIMENT 32

Object—To compare the rate of water absorbed by the roots and the amount of the water lost by transpiration in a given time.

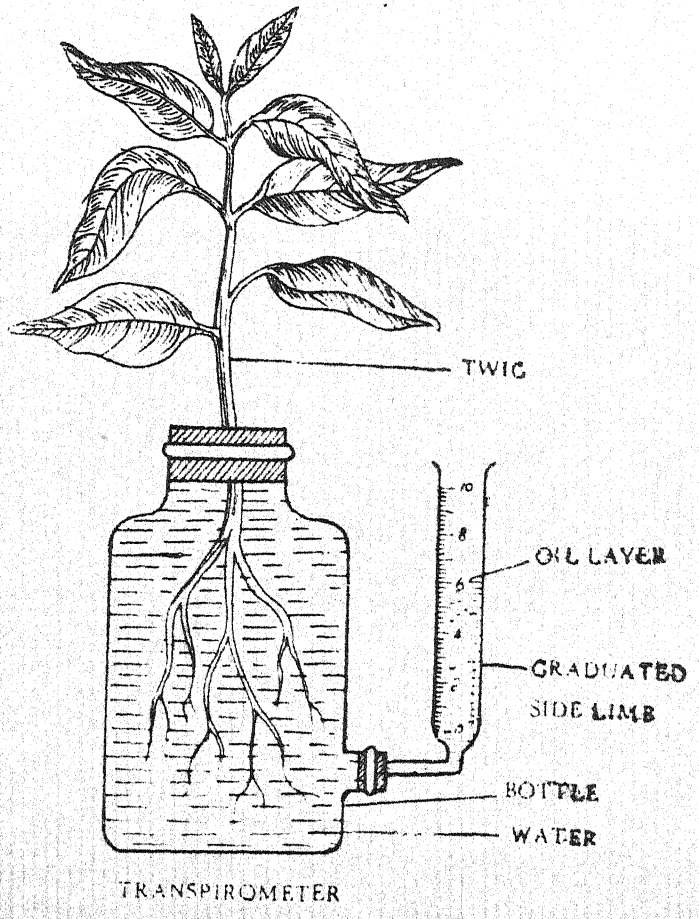
Gandy
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Requirements—Transpirometer, water, oil, a rooted plant, cork with a hole in centre, wax etc.

Procedure—Fit a graduated side tube with the wide mouth bottle. Fill it with water. Insert a freshly dug out rooted plant through the hole of the cork. The roots of the plant should be dipped in water in the bottle. A drop of oil is poured on the surface of water in the graduated side tube. Make the apparatus air-tight and then keep it in light. Mark the initial level of water in the side tube. Take the weight of the apparatus at the start. Observe the change in the level of water after some time and also the change in weight.

Observation—(i) The level of water in the side tube comes down after some time.

(ii) The weight of the apparatus taken after some time shows a decrease.



TRANSPIROMETER

Fig. 155. A Transpirometer with a rooted plant to compare the rate of absorption and the rate of transpiration in the same time.

Conclusion—In a particular time, the difference in the two weights of the apparatus shows the amount of water lost by transpiration and the difference between the readings of the water level in the side tube (side limb) shows the amount of water absorbed by the roots. The comparision of the rates shows that some times the amount of water absorbed is greater than the amount of water transpired *ie* the rate of water absorbed by the roots is not always equal to the rate of water transpirated by the plant.

Precaution

(i) The apparatus should be made air-tight.

(ii) Oil drop should be put on the water surface in the side limb to check loss of water by evaporation.

(iii) The roots should be clean and free of soil particles.

(iv) A freshly dugout plant is used in the experiment.

EXPERIMENT 33

Object—To compare the rates of transpiration of the two surfaces of a dorsiventral leaf by cobalt chloride paper.

Requirements—Cobalt chloride paper, slides, clip, leaf, beaker, water etc.

Procedure—On both the surfaces of a leaf put dried cobalt chloride papers and after covering them with two slides clip them. Observe the change in the colour of the cobalt chloride papers after some time.

Observation—The colour of the cobalt chloride paper in contact with the lower surface of the leaf turns red or pink earlier.

Conclusion—The rate of transpiration of the lower surface of the leaf is rapid than the upper surface. i.e. the rate of stomatal transpiration is more than the cuticular transpiration.

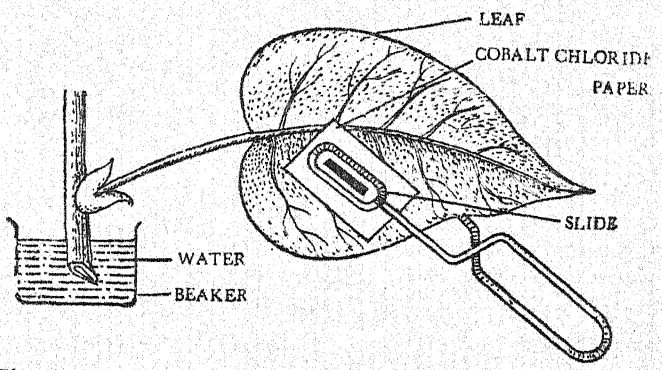


Fig. 156. Showing comparision of the rates of stomatal and cuticular transpiration by cobalt chloride paper.

Precaution

(i) The cobalt chloride papers should be covered by glass slides to check the effect of atmospheric moisture.

(ii) The cobalt chloride papers should be dried (moisture free and be always kept in the desicator.

(iii) The leaf taken for the experiment should be a dorsiventral leaf.

EXPERIMENT 34

Object—To compare the rates of transpiration by four leaf experiment.

Requirements—4 Leaves, 3 clamp stands, grease or vaseline and thread.

Procedure—Take a leaf and grease both the surfaces. Now take another leaf and grease only the lower surface. Take yet another leaf and grease the upper surface. Leave both the surfaces of the fourth leaf ungreased. Tie them to a thread and hang with the help of the thread and two stands as shown in the figure. Observe each one after a certain time and note their behaviour.

Observation—(i) The first leaf with grease applied on both the surfaces remains as such.

(ii) The leaf greased only on the lower surface becomes dried.

(iii) The third leaf greased on the upper surface seems to be more dried incomparision to the second leaf.

(iv) The fourth leaf which was ungreased dries out most.

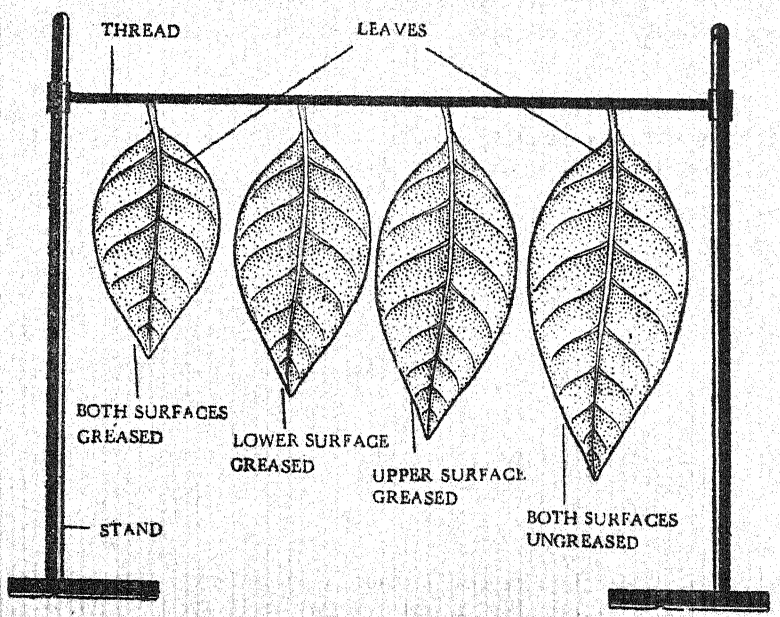


Fig. 157. Showing four leaf experiment on *transpiration*.

Conclusion

(i) In case of the first leaf as both the surfaces are greased, both

stomatal and cuticular transpiration is checked. There is no loss of water and thus the leaf remains as such.

(ii) In second leaf as lower surface is greased, stomatal transpiration is checked. Only cuticular transpiration takes place and as the rate of cuticular transpiration is slower than the stomatal transpiration, the leaf slightly dries out.

(iii) In case of the third leaf as the upper surface is greased, cuticular transpiration is checked but stomatal transpiration takes place. Thus the leaf dries out more in comparision to the second leaf.

(iv) The fourth leaf dries out most because both stomatal and cuticular transpiration is taking place and the leaf loses water from both the surfaces.

Precaution

(i) The greased surfaces should be throughly greased.

(ii) The cut surfaces of the petioles of the leaves should also be greased to check transpiration from the cut surfaces.

EXPERIMENT 35

Object—To demonstrate quantitative measurement of differential rates of transpiration from both upper and lower surfaces of a leaf by *Garreau's potometer.*

Requirements—A potted plant, stool, 2 small bell jars, 2 small tubes, manometer, oil, cork, a bent glass rod, anhydrous calcium chloride, stand, thread, vaseline, glycerine, wax, mercury etc.

Procedure—Place two small bell jars one above the other. Place a leaf in between the two bell jars when the leaf is still attached to the potted plant. Take anhydrous calcium chloride in two small tubes and weigh them separately. Keep these tubes (with calcium chloride) at the narrow ends of the bell jars. Make the broad rims of the bell jars in contact with the leaf surface air-tight with the vaseline. Attach two oil manometers at the two ends of the bell jars. Clamp the whole apparatus vertically on a stand. After some time take out the two small tubes and again weigh them. During this experiment also see the change of level of oil in the manometer.

Observation—(i) There is increase in the weight of the two small tubes after some time.

(ii) There is no change in the level of oil in the manometers.

Conclusion—(i) The increase in weight is due to the absorption of water vapours lost by the leaf surfaces during transpiration and the difference between the two weighings indicates the amount of water lost from the leaf surfaces. There is greater increase in the weight of the tube kept in the lower bell jar because the lower surface loses more amount of water than the upper surface.

(ii) No change in the level of oil in the manometers indicates that the apparatus is air-tight and the water lost by the leaf surfaces is absorbed by the anhydrous calcium chloride kept in the small tubes. It may be pointed

out, here, that any change seen in the manometer is indicative of the fact that either the apparatus is not air-tight or all the water vapour given out by the leaf surfaces is not being absorbed by the calcium chloride kept in the small tubes.

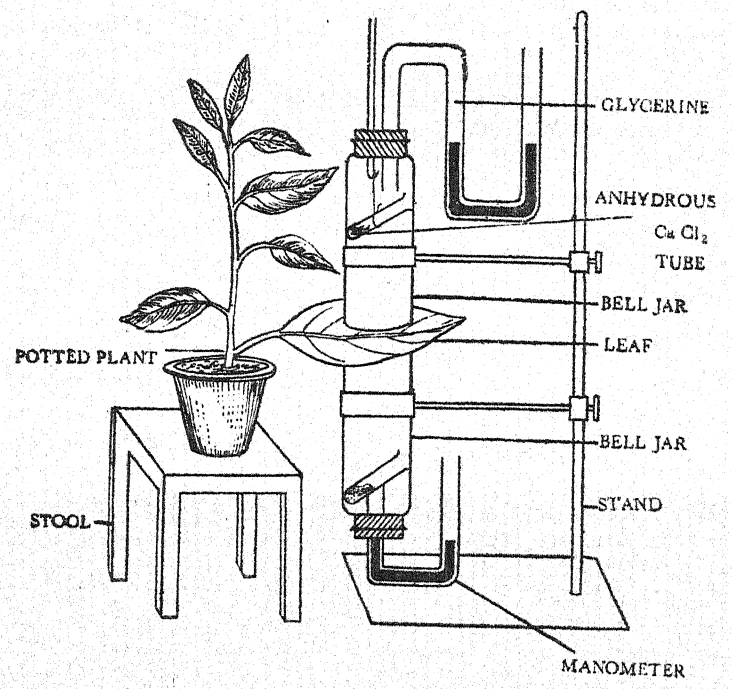


Fig. 158 Showing Garreau's potometer to demonstrate quantitative measurement of differential rates of transpiration from the upper and the lower surface of a leaf while the leaf is still attached to a potted plant.

Precaution—(i) The apparatus should be air-tight.

(ii) Calium chloride kept in the small tubes should be anhydrous.

(iii) The apparatus should be kept in sun light.

(iv) The bell jars should be dry from inside.

[Note —The oil in the manometer can be replaced by mercury and glycerine.]

EXPERIMENT 36

Object—To demonstrate the loss in the total weight during transpiration.

Requirements—2 leaves of almost equal sizes and ages, grease, water, test tubes, corks, 2 spring balances, two stands, wax, and thread.

Procedure—Take the two leaves of almost equal sizes and ages. Apply grease on both the surfaces of one of them and leave the other leaf as such.th

Take two test tubes containing water and insert the leaves through the holes in the corks. See that the petioles of the two leaves are dipped in water. Hang the two air-tight test tubes on the two spring balances and note the weights separately. Keep the apparatus in sun light for a few hours and then again note the weights of the test tubes.

Observation—There is no change in the weight of the test tube B, but the weight of A decreases.

Conclusion—There is no difference in B because both the leaf surfaces are greased and thus there is no transpiration (water loss). But the loss in weight of the test tube A is due to loss of water in transpiration as the leaf is in the normal state and loses water from both the surfaces. This thows that there is loss in the total weight of a plant or a leaf during sranspiration.

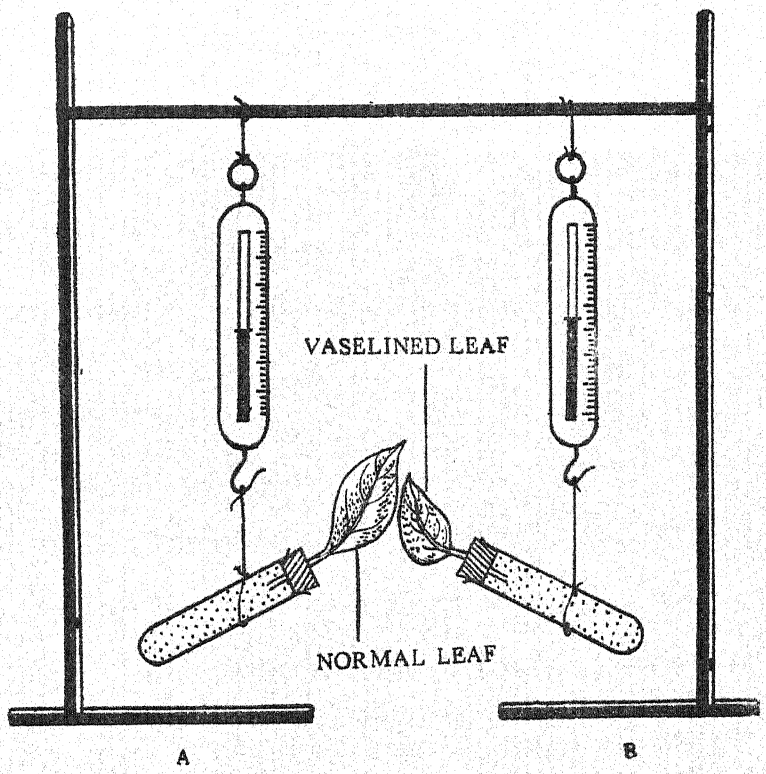


Fig. 159. Showing apparatus to show the loss of weight of a leaf during transpiration.

Precaution—(i) The test tubes should be air-tight.

(ii) The petioles should be dipped in water.

(iii) The apparatus should be kept in sun light.

EXPERIMENT 37

Object—To demonstrate transpiration by *Erlenmayer flask.*

Requirements—A potted plant, Erlenmayer flask, water, wax and a rubber cork (in two pieces).

Procedure—Take a potted plant. Insert a branch of the plant inside the Erlenmayer flask through the cork. Make the flask air-tight with the wax. Water the pot occasionaliy and observe carefully the inner surface of the Erlenmayer flask.

Observation—Condensation of water takes place in the form of drops on the inside of the flask.

Conclusion—Loss of water takes place during transpiration.

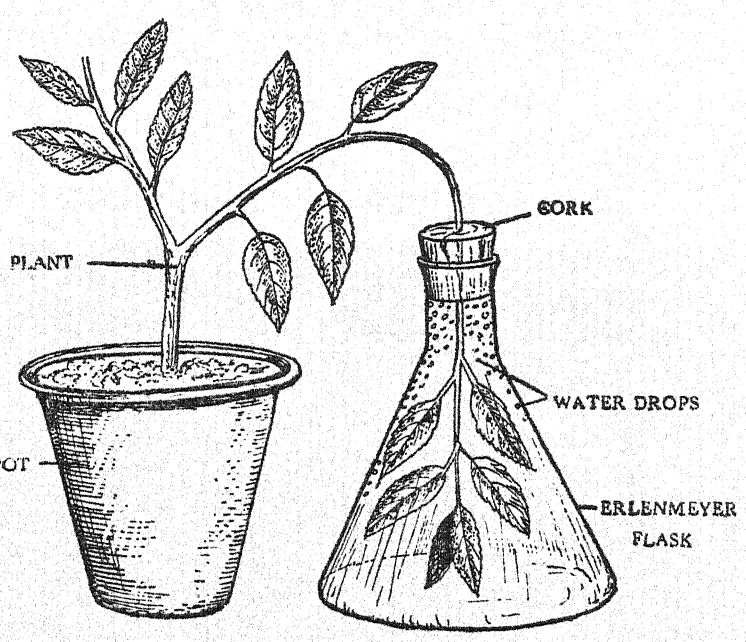


Fig. 160. To demonstrate loss of water during transpiration by the Erlenmayer flask.

Precaution—(i) The flask should be air-tight.

(ii) The flask should be completely dry from inside.

(iii) The experiment is performed in open air.

(iv) The pot is watered occasionally.

EXPERIMENT 38

Object—To demonstrate the continuity of the intercellular spaces of a leaf with the outer atmosphere through the stomata.

Requirements—A big leaf, a bottle, a rubber cork with two holes, water, L-shaped glass tube, rubber tube, water tap and wax.

Procedure—Take a big leaf and cut its petiole (from the base) under water. Insert the petiole of the leaf, through one of the two holes of the cork, in the bottle containing water. The cut end should be dipped in water. Insert the L-shaped glass tube in the bottle through the cork. The end should be above the surface of the water. Connect the other end of the tube to an aspirator. Make the apparatus air-tight. After setting in action of the aspirator, observe the bottle carefully.

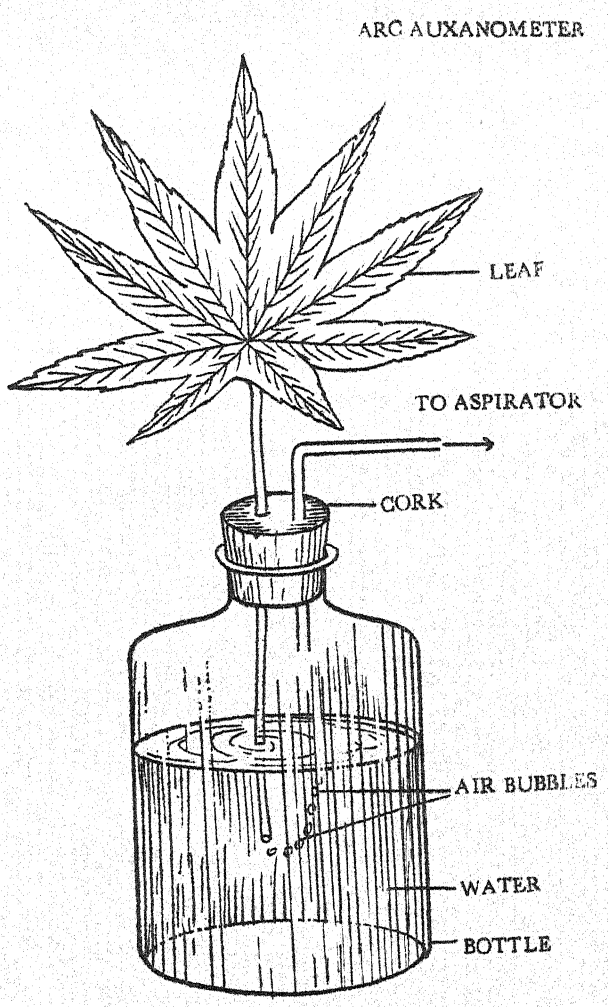


Fig. 161. Showing the continuity of the air spaces of a leaf with the outside atmosphere through the stomata.

Observacion—A continuous stream of bubbles come out from the cut end of the petiole.

Conclusion—This shows the continuity of the intercellular spaces of the leaf with the outer atmosphere through the stomata. When the aspira-

tor starts working, it sucks the air from the bottle and vacuum is created. As a result to this the air enters the stomata of the leaf and passing through the air spaces comes to water through the petiole and can be seen in the form of bubbles.

Precaution—(i) The apparatus should be air-tight.

(ii) The petiole of the leaf should be cut inside water to maintain the continuity of water column in the xylem of the leaf.

EXPERIMENT 39

Object—To demonstrate *guttation* with the help of a potted plant.

Requirements—A young potted plant of garden nasturtium (*Tropaeolum majus*) of Tropaeolaceae, water, a bell jar, cork with a hole, L-shaped glass tube, rubber sheet, rubber tube, glass plate, aspirator, wax and grease.

Procedure—Take a young potted plant of garden nasturtium and keep it on a glass plate. Cover the pot soil with the rubber sheet. Now cover the pot with a bell jar. Insert one end of the glass tube inside the bell jar through the cork and connect the other end to an aspirator. Make the apparatus air-tight and keep it in a cool and dark place. Observe the experiment after one or two hours.

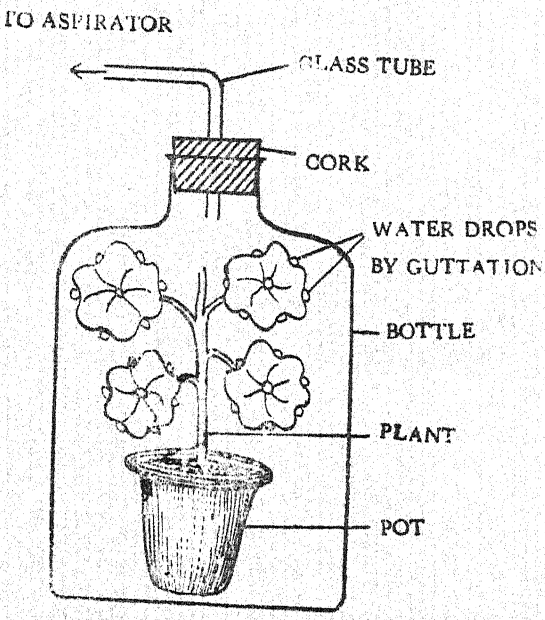


Fig. 162. Showing *guttation*.

Observation—Water drops appear at the margins of the leaves.

Conclusion—As soon as the aspirator is set to work, it sucks the air of the bell jar. As a result to this vacuum is created. This develops a

force within the cells of the leaves. The water is forced out through the *hydathodes* in the form of droplets. This is due to *guttation.*

Precaution—(i) The apparatus should be air-tight.

(ii) It should be kept in a cool and dark place (to check transpiration).

(iii) The soil of the pot is covered by a rubber cloth to check evaporation of the water of the soil.

EXPERIMENT 40

Object—To demonstrate that light is necessary for *photosynthesis.*

Requirements—A normal potted plant, Ganong's Light Screen, spirit lamp, small beaker, petridishes, iodine solution, ethyl alcohol etc.

Procedure—Keep the potted plant in dark for 24 hours. The leaves of the potted plant are destarched. Fix Ganong's Light Screen to one of leaves of the potted plant. A certain area (part) of the leaf is thus covered but there is a star-shaped area of the leaf in the centre of the Ganong's Light Screen which receives light. Keep the experiment in sun light for eight hours. Now pluck out the leaf and boil it in ethyl alcohol. Apply iodine solution and test for starch.

Observation—By boiling in the ethyl alcohol the leaf loses its chlorophyll and when tested for idodine reaction, it is observed that the part of the leaf covered by the Ganong's Light Screen gives negative test with iodine but the central part which is exposed to light and all other parts which receive light give a positive test.

Conclusion—The area of the leaf covered by the Ganong's Light Screen, gives negative test with iodine because it is not getting light. Thus this experiment proves that light is a necessary factor for photosynthesis.

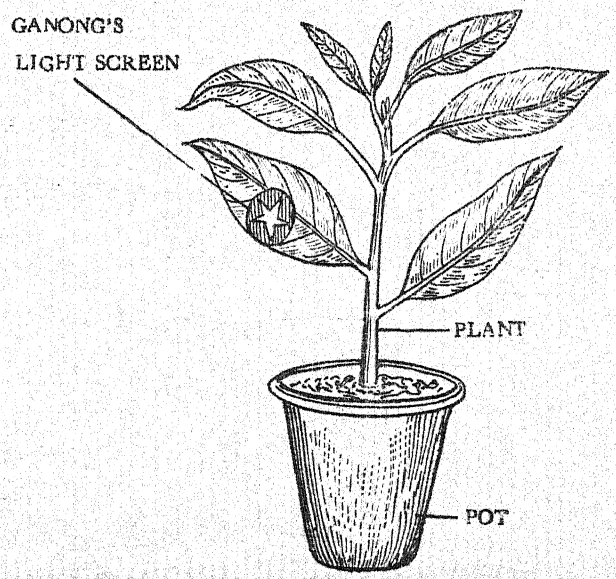


Fig. 163. Experiment to demonstrate that light is necessary for photosynthesis by Ganong's Light Screen.

Precaution—(i) The leaves of the plant should be normal and not spotted (variegated).

(ii) The leaves should be destarched before starting the experiment.

(iii) The Ganong's Light Screen should be closely attached to the leaf.

EXPERIMENT 41

Object—To demonstrate that *chlorophyll* is necessary for *photosynthesis*.

Requirements—A potted plant with variegated leaves, iodine solution, ethyl alcohol, spirit lamp, beaker, petridishes etc.

Procedure—Keep the potted plant with variegated leaves for 24 hours in dark to destarch the leaves. Now keep the pot in sunlight for 8 hours. Pluck out a leaf and test for iodine reaction after boiling in ethyl alcohol to remove the chlorophyll.

Observation—The portions of the leaf which were devoid of chlorophyll (in the beginning of the experiment) give negative test with iodine and the portions which were originally green and contained chlorophyll give positive test with iodine.

Conclusion—The portions of the leaf giving negative test with iodine show that those areas are dovoid of chlorophyll. Thus chlorophyll is necessary for photosynthesis.

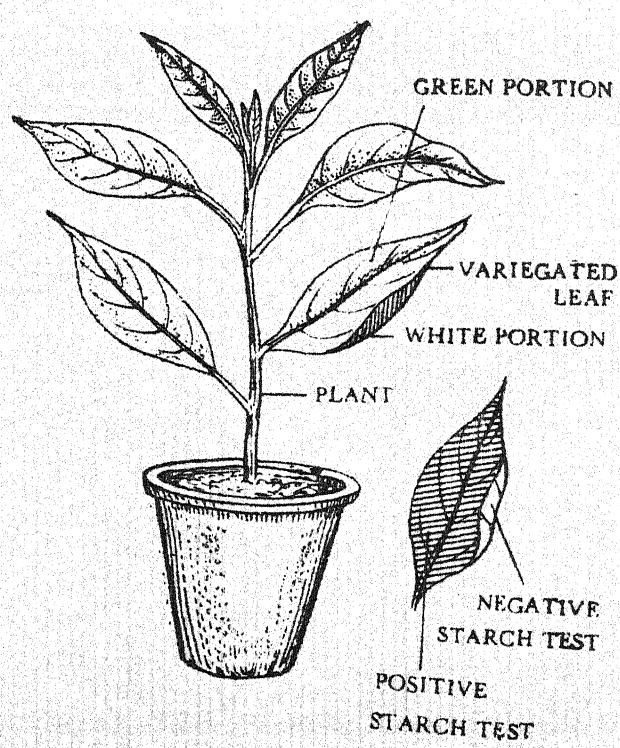


Fig. 164. Experiment to demonstrate that chlorophyll is necessary for photosynthesis.

Precaution—(i) The leaves should be destarched before starting the experiment.

(ii) The leaves should be variegated.

(iii) The plant should be exposed to sufficient light.

EXPERIMENT 42

Object—To demonstrate that *carbon-di-oxide* is necessary for *photosynthesis* by Moll's experiment.

Requirements—A potted plant, a bottle, rubber cork (in two pieces), potassium hydroxide solution, ethyl alcohol, beaker, petridishes, wax, iodine solution, spirit lamp etc.

Procedure—Take a potted plant and keep it in dark for 24 hours to destarch its leaves. Take a little amount of potassium hydroxide solution in the bottle. Now insert the leaf through the rubber cork half inside and half outside the bottle. Make the bottle air-tight. Keep this experiment in sunlight for a sufficient time and test the leaf for iodine reaction.

Observation—The portion of the leaf kept in the bottte, and also the cork gives negative test but the portion of the leaf outside the bottle gives positive test.

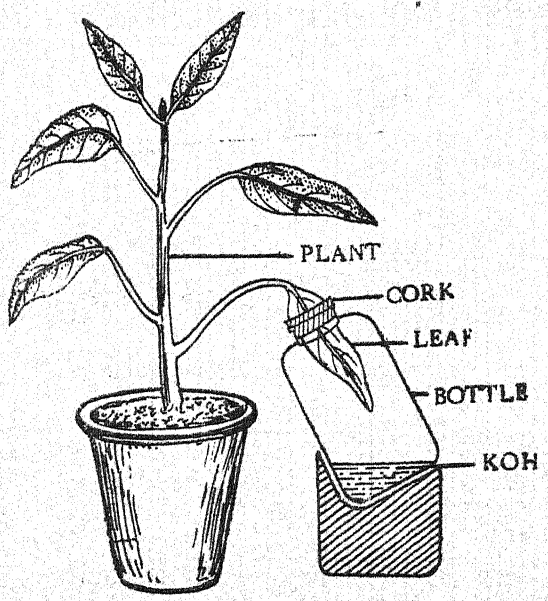
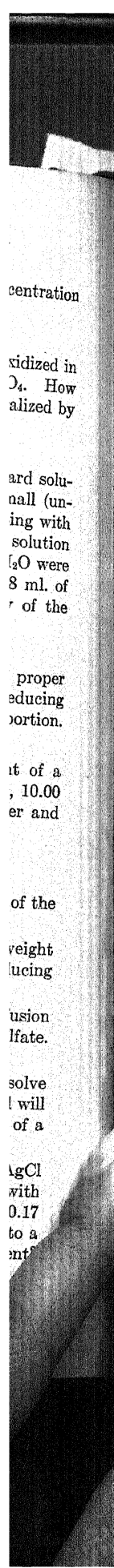


Fig. 165. Experiment to demonstrate that carbon-di-oxide is necessary for photosynthesis by Moll's experiment.



Conclusion—(i) The portion of the leaf inside the bottle gives negative test with iodine because this portion is not getting carbon-di-oxide. Carbon-di-oxide present in the air (in the bottle) is absorbed by the potassium hydroxide solution kept in the bottle, although this portion of the leaf is exposed to light.

(ii) The portion of the leaf inside the cork also gives negative test with iodine because it is not getting light.

(iii) The portion of the leaf outside the bottle has all the three necessary factors for photosynthesis namely, *light, carbon-di-oxide* and *chlorophyll* and thus this portion of the leaf gives positive test with iodine.

Precaution—(i) The leaves of the plant should be destarched before starting the experiment.

(ii) The plant should be kept in sunlight for sufficient time.

(iii) The apparatus should be air-tight.

EXPERIMENT 43

Object—To demonstrate that the evolution of *oxygen* takes place during the process of *photosynthesis*.

Requirements—A beaker, water, a funnel, a test tube and *Hydrilla* (Hydrocharidaceae) plants.

Procedure—Fill the beaker with water. Keep a few *Hydrilla* plants in the beaker and put an inverted funnel on the plants. Now fill a test tube with water and keep it inverted on the funnel. The narrow end of the funnel should be dipped in water. Keep the apparatus in sunlight and observe the evolution of bubbles through the narrow end of the funnel.

Observation—The bubbles comming out are collecting at the top of the test tube. When tested, the gas is proved to be *oxygen*.

Conclusion—Evolution of oxygen takes place during the process of photosynthesis.

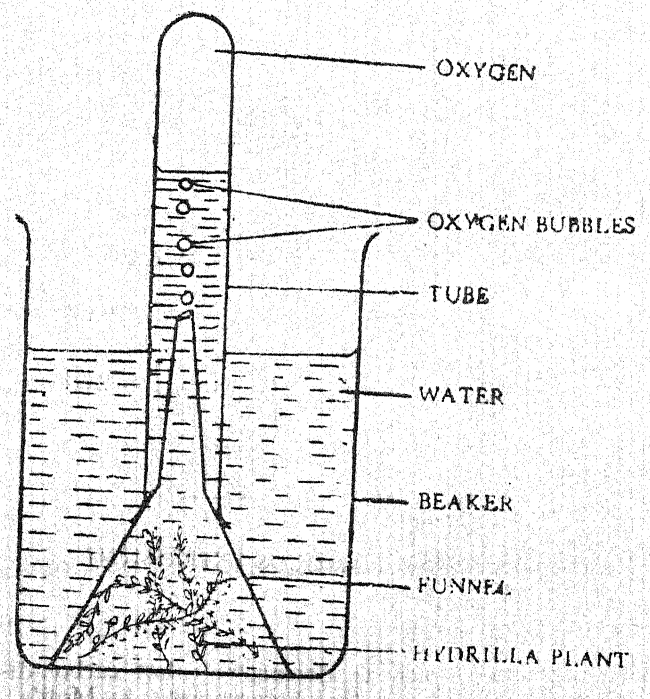


Fig. 166. Experiment to show that oxygen is evolved during photosynthesis.

Precaution—(i) The apparatus is kept in sun light.

(ii) The narrow end of the funnel should be kept in water.

(ii) The plant kept in the beaker (covered by the funnel) must be a water plant.

EXPERIMENT 44

Object—To demonstrate the effect of the common salt, on the rate of photosynthesis, when added in water.

Requirements—Two beakers, water, 2 funnels, 2 test tubes, *Hydrilla* plants and common salt.

Procedure—Set the experiment like the previous experiment (experiment 43). Add a little amount of common salt (Nacl) in the water contained in the beaker (A). Set a similar experiment without adding common salt for comparison i.e. control experiment (B). Observe carefully the rates of the evolution of the bubbles in A & B after keeping the experiments in sun light.

Observation—The rate of evolution of the bubbles (oxygen) in experiment A is very slow and ultimately stops but in the B the rate of evolution of oxygen is normal.

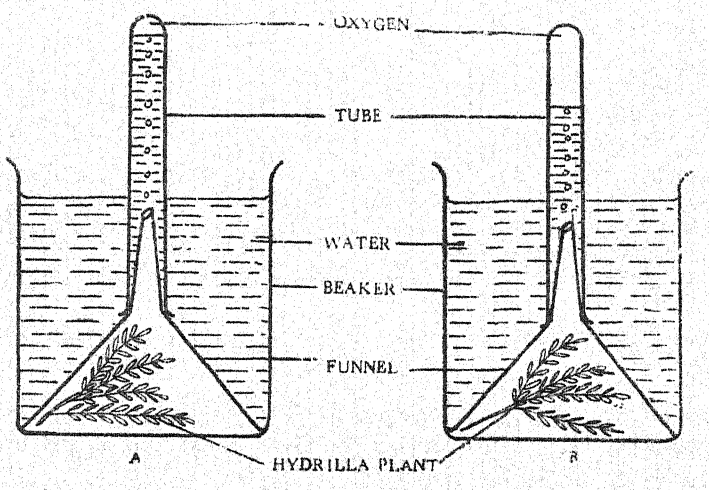


Fig. 167. To demonstrate the effect of common salt (adden in water) on the rate of photosynthesis of *Hydrilla* plant. In A, common salt is added and B is the control experiment.

Conclusion—In the experiment A, after some time, *exosmosis* takes place. The water of the cell sap (of the cells of *Hydrilla* plant) moves out and the contents shrink. The activity of the cells becomes slower. As a result to *plasmolysis* bubble formation stops. Thus common salt not only decreases the rate of photosynthesis but ultimately stops it.

Precaution—(i) The experiment is performed in sun light.

(ii) The narrow ends of the funnel should be dipped in water.

(iii) The plant kept in the beaker must be a hydrophyte.

EXPERIMENT 45

Object—To find out the effect of different wavelenghts of light on the rate of photosynthesis i. e. the effect of : (a) red light, and (b) blue light.

Requirements—2 troughs, 2 beakers, 2 test tubes, 2 funnels, *Hydrilla* plants, water, red coloured solution, blue coloured solution etc.

Procedure—Set two experiments A & B like experiment no. 43. Here common salt is not added. Keep two experiments in two separate troughs containing red and blue solutions separately. Observe the rates of bubbling in the two experiments.

Observation—The rate of evolution of the bubbles (oxygen) is faster in A (trough containing red solution).

Conclusion—The rate of photosynthesis is more in red light than in blue light.

Precaution—The experiment should be kept in sun light for sufficient time.

Modifications

(i) **Question**—What will happen when sodium bicarbonate ($NaHCO_3$) is added in water ?

Answer—The rate of photosynthesis is increased because sodium bicarbonate breaks down and carbon-di-oxide is liberated. The increased amount of carbon dioxide increases the rate of photosynthesis. Further additions of sodium bicarborate will go on increasing the rate of photosynthesis provided light does not become the limiting factor.

(ii) **Question**—What will happen if sodium carbonate is added in water ?

Answer—Sodium carbonate is not broken down. It will not liberate carbon dioxide. Thus there will be no effect on the rate of photosynthesis.

(iii) **Question**—What will be the effect on the rate of photosynthesis if anaesthetics are added in water ?

Answer—The protoplasm of the plant cells are inactivated and paralysed. The rate of photosynthesis either decreases codsiderably or photosynthesis stops altogether as ultimately the cells are killed.

(iv) **Question**—What will happen if the water is replaced by the water which was first boiled and then after cooling was taken for the experiment ?

Answer—On boiling the carbon dioxide dissolved (present) in the water is removed. Thus the water which was first boiled and then cooled is free of carbon dioxide. So there will be no photosynthesis as carbon dioxide is necessary for photosynthesis.

(v) **Question**—What will happen if the water contained in the beaker is first warmed and later on boiled ?

Answer—On warming or slightly raising the temperature of water, the rate of photosynthesis increases but on boiling the protoplasm will be killed and there will be no photosynthesis.

(vi) **Question**—What will happen if the experiment is kept in intermittent light ?

Answer—The rate of photosynthesis increases in intermittent light in comparision to continuous light. In photosynthesis carbohydrates are formed. In continuous light the carbohydrates are not converted into sugars. They accumulate and decrease the rate of photosynthesis. In intermittent light the carbohydrates are converted into sugars (in dark) and there is always a vacuum which increases the rate of photosynthesis.

(vii) **Question**—What will happen if potassium hydroxide is added in water ?

Answer—There is no photosynthesis because carbon dioxide is absorbed by potassium hydroxide and secondly because *plasmolysis* occurs.

(viii) **Question**—What will happen if poison (potassium cyanide) is added in water ?

Answer—There will be no photosynthesis because the protoplasm will be killed and will become inactive.

(ix) What will happen if water plant is replaced by a land plant ?

Answer—The leaves of the land plant have stomata which are closed in water. The water will not enter into the plant and as the water is the only source of carbon dioxide, in absence of which there will be no photosynthesis.

EXPERIMENT 46

Object—To demonstrate the effect of different wavelengths of light on the rate of photosynthesis by Ganong's Light Screen.

Requirements—A potted plant, Ganong's Light Screen, iodine solution, beaker, ethyl alcohol, water, petridishes, spirit lamp etc.

Procedure—Take a potted plant. Keep it in dark for 24 hours to destarch its leaves. Fix one one of the leaves in the Ganong's Light Screen. Cover a part of the box with a red glass plate ; a part with a green glass plate and a part with a blue glass plate. Avoid direct sun light. Leave the experiment for about 8 hours and then in the evening remove the leaf (fixed in the Ganong's Light Screen) and test for starch after boiling the leaf in alcohol to remove chlorophyll.

Observation—The leaf gave positive iodine test. It was also noted that the part of the leaf under red light (red glass plate) was deep blue, the part of the leaf under blue glass plate took lighter stain and the part under green plate was very light.

Conclusion—The rate of photosynthesis is more in red light in comparision to blue and green lights.

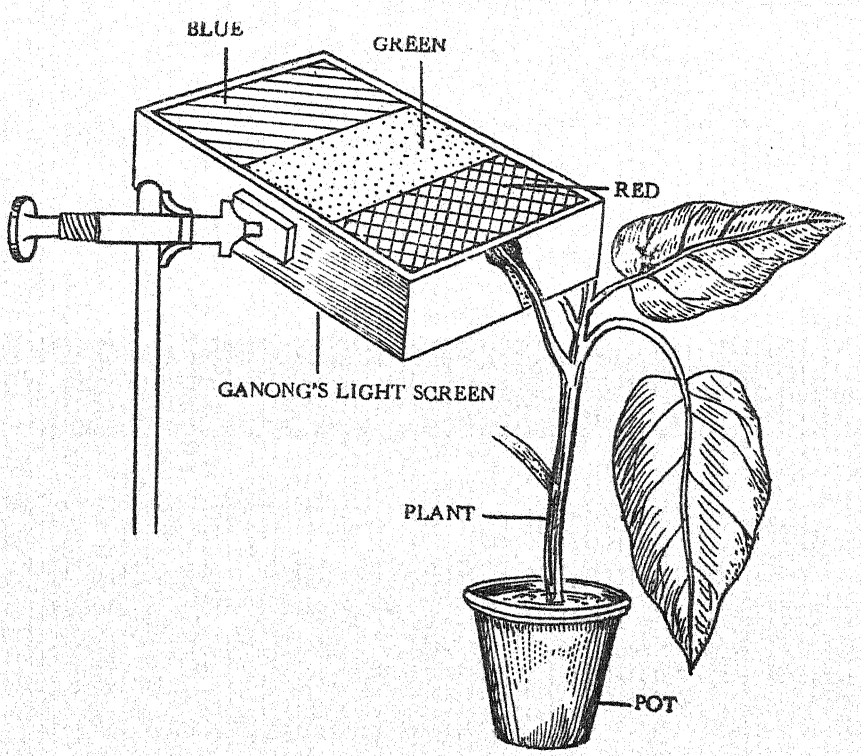


Fig. 168. Demonstration of the effect of light (of different wave lengths) on the rate of photosynthesis with the help of Ganong's Light Screen.

Precaution—(*i*) Leaves of the potted plant are destarched before starting the experiment.

(ii) Direct sun light should be avoided.

EXPERIMENT 47

Object—To demonstrate the process of ***respiration*** in the absence of ***oxygen*** (***anaerobic respiration***).

Requirements—Test tubes, mercury, petridishes, stands, potassium hydroxide crystals, forceps, germinating gram seeds, etc.

Procedure—Take a petridish and fill it half with mercury. Take a test tube and fill it completely with mercury. Put this test tube filled with mercury in the petridish in inverted position. Now introduce a few soaked and germinating gram seeds into the test tube with the help of the forceps. The germinating seeds are kept at the top in the test tube where there is no oxygen or air. Keep the apparatus after fixing with a stand as shown in the fig. (A) for a few hours and then observe.

Observation—The level of mercury in the test tube falls down (B). The level of mercury is raised if potassium hydroxide (KOH) crystals are introduced in the test tube.

Conclusion—The level of mercury falls because the seeds give out some gas which presses the mercury level to fall down. When potassium hydroxide crystals are introduced, the level rises. This shows that the gas given out by the seeds is absorbed by potassium hydroxide crystals confirming that the gas is carbon dioxide.

The above experiment shows that germinating seeds respire anaerobically even in the absence of oxygen. This can be shown by the following equation:

$$C_6H_{12}O_6 = 2CO_2 + 2C_2H_5OH$$

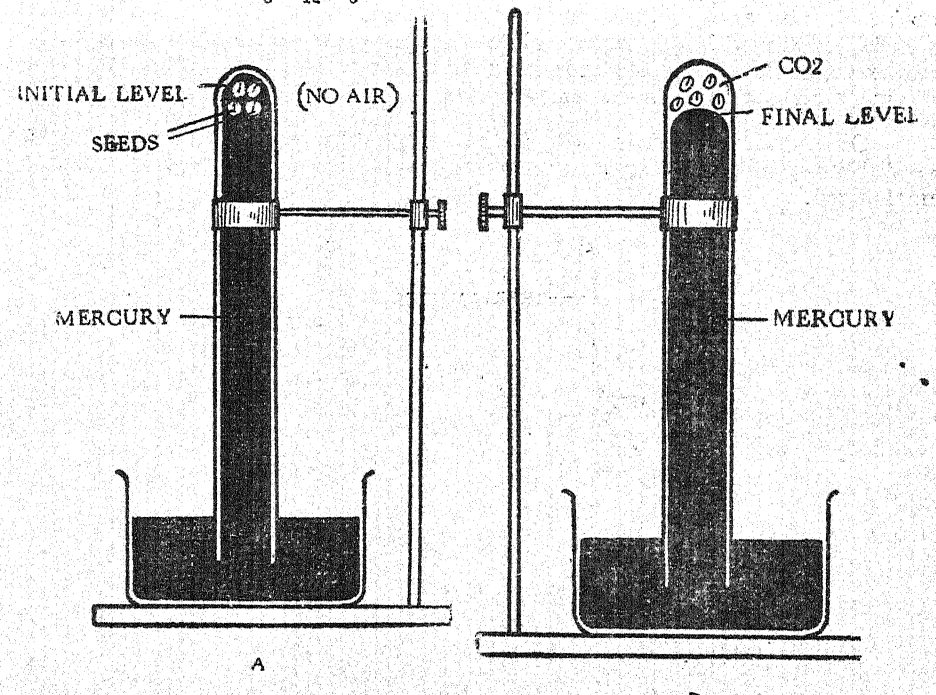


Fig. 169. Demonstration of anaerobic respiration. (A) shows the initial level and (B) shows the final level of the mercury in the test tube after carbon dioxde is evolved in the process of respiration and is accumulated at the top.

Thus the process of respiration can take place even in the absence of oxygen and carbon dioxide is still released.

Precaution—(i) No air should be left in the test tube in (A).

(ii) Soaked germinating seeds are taken for the experiment.

(iii) Care should be taken in the introduction of possium hydroxide crystal.

(iv) The apparatus should be air-tight.

EXPERIMENT 48

Object—To demonstrate that energy is liberated in the form of heat in the process of respiration.

Requirements—2 thermos-flasks, 2 thermometers, germinating seeds, mercuric chloride, rubber corks etc.

Procedure—Take two thermos-flasks A and B. Take normal germinating seeds in one of the two flasks. Close the flask with the rubber cork and insert a thermometer through the hole of the cork. In the other flask take boiled or dried seeds after treating them with mercuric chleride to eliminate *fungi* and also to prevent respiration. Close the flask by rubber cork and insert another thermometer through the hole. The thermometers should be burried in the seeds. Note the temperatures at the begining of the experiment. Allow the experiment to continue for some time and then again note the change in the temperatures.

Observation—There is a rise in the temperature in caee of germinating seeds but the temperature in the other case with killed seeds remains unchanged.

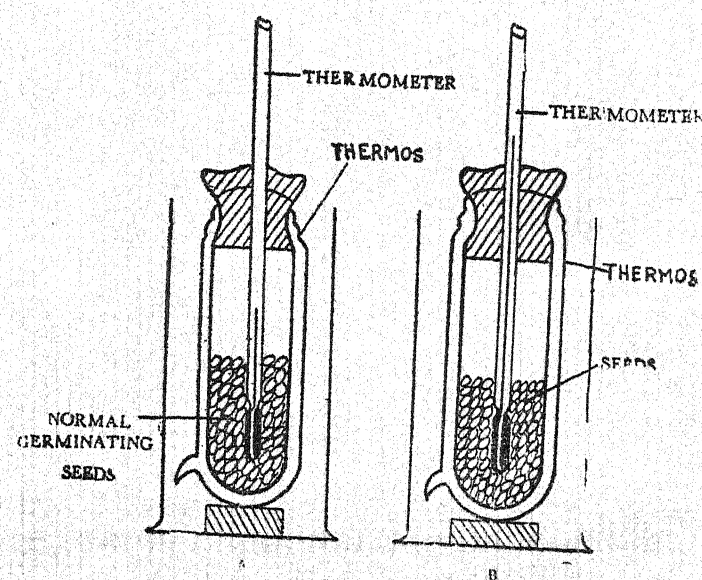


Fig. 170. Experiment set up to demonstrate that energy in the form of heat is evolved during respiration.

Conclusion—In case of normal germinating seeds respiration takes place. The energy released in the break down of the respiratory substrate is utilised in other metabolic processes of the cell but at the same time a part of the energy escapes in the form of heat. This raises the temperature.

$$C_6 H_{12} O_6 = 2 CO_2 + 2 C_2 H_5 OH + Energy$$

In case of the killed seeds no respiration takes place and energy is not evolved. Thus the temperature remains unchanged in this case.

Precaution :

(i) The apparatus (flasks) should be air-tight.

(ii) The thermometers should be burried in the seeds.

(iii) The seeds of (B) should be treated with mercuric chloride to kill fungi and bacteria.

EXPERIMENT 49

Object—To demonstrate the process of *fermentation* by *Kuhne's fermentation vessel.*

Requirements—Kuhne's fermentation vessel, water, glucose, beaker, baker's yeast etc.

Procedure—Prepare a 10% glucose solution in a beaker and add a small quantity of baker's yeast to this solution. Pour to mixture into *Kuhne's fermentation vessel* and fill the tube completely and only half of the bulb. Plug the month of the bulb and leave the experiment for a few hours and then observe.

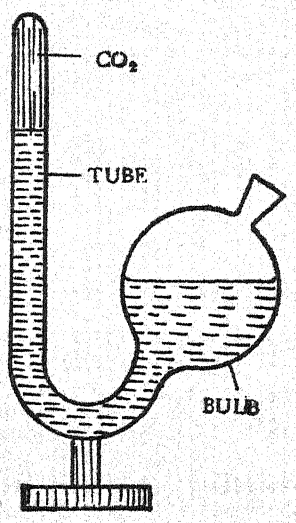


Fig. 171. Kuhne's fermentation vessel showing fermentation. The level of the solution has fallen down due to accumulation of carbon dioxide gas in the tube.

Observation—The level of the glucose solution falls down in the straight tube.

Conclusion—The level falls down due to fermentation in which carbon dioxide gas is evolved. The solution can now be smelled. The smell is that of fermented glucose solution i. e. that of alcohol. The gas can be tested by introducing caustic potash into the vessel. Here an *enzyme, zymase,* and a *coenzyme, phosphate* present in the yeast cells brings about the process of fermentation. It can be summarised as below :

(i) $2\,C_6\,H_{12}\,O_6 + 2\,R_2\,HPO_4 = 2\,CO_2 + 2\,C_2\,H_5\,OH + 2H_2O + C_6H_{10}O_4\,(R_2PO_4)_2$

[Hexose diphosphate]

(ii) $C_6\,H_{10}\,O_4\,(R_2\,PO_4)_2 + 2H_2O = 2R_2\,HPO_4 + C_6\,H_{12}\,O_6$

Therefore, the final equation is as follows :

$$C_6\,H_{12}\,O_6 = 2\,CO_2 + 2\,C_2H_5OH$$

Precaution

(i) The mixture of the glucose solution and baker's yeast should be throughly shaken.

(ii) The upright arm of the Kuhne's fermentasion vessel should be completely filled.

(iii) The apparatus should be kept in a warm place.

EXPERIMENT 50

Object—To demonstrate that carbon dioxide is liberated during aerobic respiration by *Ganong's respirometer*.

Requirements – Ganong's respirometer, stand, potassium hydroxide solution, rubber tube, mercury, germinating seeds, mercuric chloride solution etc.

Procedure—Keep some germinating seeds in the retort and fill the graduated tubes with KOH solution. The level of the solution in both the tubes should be equal. Make the apparatus air-tight and observe after some time the change in the level.

Observation—The level in the tube rises.

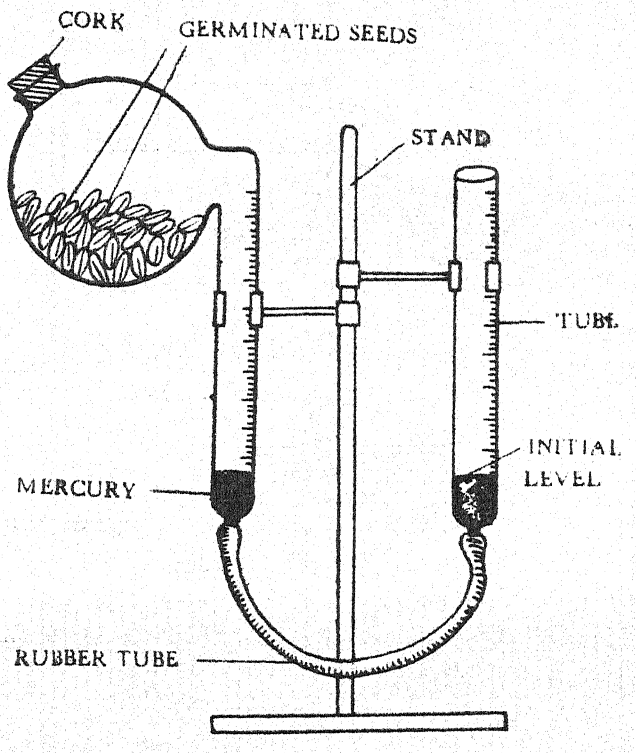
Conclusion—In aerobic respiration oxygen is absorbed and carbon dioxide is liberated but carbon dioxide is absorbed by the potassium hydroxide solution. This creates a vacuum in the retort. As a result to it the level of potassium hydroxide solution in the graduated tube rises.

Precaution

(i) Seeds must be washed with mercuric chloride solution to kill fungi and bacteria.

(ii) Seeds should be germinating.

(iii) The apparatus should be air-tight.



GANONG'S RESPIROMETER

Fig. 172. Experiment set up to demonstrate that carbon dioxide is evolved during aerobic respiration.

EXPERIMENT 51

Object—To demonstrate that carbon dioxide is liberated during the process of *aerobic respiration.*

Requirements—A retort, cork, germinating seeds, potassium hydroxide solution, stand, trough etc.

Procedure—Take a few germinating seeds in the retort. Plug it. Take potassium hydroxide solution in a trough. Fix the retort with the help of a stand in such a way that end of the tube of the retort is dipped in possium hydroxide solution. Note the rise of level of possium hydroxide solution in the tube after some time.

Observation—The level of the solution in the tube rises.

Conclusion—During respiration carbon dioxide gas is liberated. This gas is absorbed by the potassium hydroxide solution present in the tube of the retort. A vacuum is created in the retort and this raises the level of the solution in the tube.

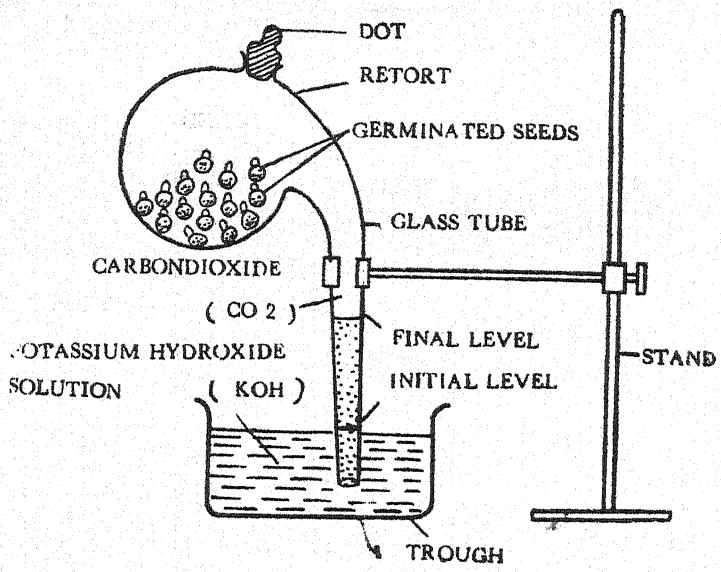


Fig. 173. Showing evolution of carbon dioxide during aerobic respiration.

Precaution

(i) The apparatus should be made air-tight.

(ii) The tip of the glass tube of the retort should be dipped in potassium hydroxide solution.

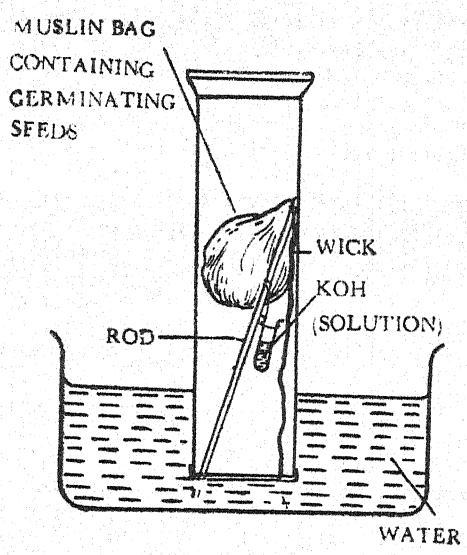
(iii) The seeds should be germinating.

EXPERIMENT 52

Object—To demonstrate that only one fifth air (oxygen) is used during respiration by *Tamhane's experiment.*

Requirements—Trough, water, a small tubs, glass rod, potassium hydroxide solution, bell jar, muslin bag, germinating *pea* seeds etc.

Procedure—Keep some germinating seeds in a muslin bag. Take a little potassium hydroxide solution in a small tube. Tie the bag containing the germinating seeds and the small tube to a glass rod with the help of a thread. Put the rod in a trough containing water and cover it with a jar as shown in the figure. A cotton wick is attached to the bag to keep the bag moist. The bell jar is divided into 5 equal parts and marked. Observe this experiment after one or two days.



TAMHANE EXPERIMENT

Fig. 174. Experiment to demonstrate that only on fifth of the air is used in the process of respiration by *Tamhane's experiment*.

Observation—The water rises in the bell jar upto 1/5th part.

Conclusion—Only 1/5th of the air is utilised in the process of respiration. The experiment is not affected by the liberation of carbondioxide as it is absorbed by potassium hydroxide solution kept in the small tube.

Precaution

(i) The apparatus should be air light.

(ii) Seeds should be germinating.

(iii) Only muslin cloth should be used so that the radicles should receive air.

(iv) Potassium hydroxide must be kept to absorbe the carbon dioxide liberated during respiration.

EXPERIMENT 53

Object—To demonstrate the value of R. Q. (*fatty seeds*), succulent cactus pieces (*organic acid*) and seeds of gram (*carbohydrate*).

Requirements—Three test tubes with their corks, 3 capillary tubes, trough, water, stands with clamps, and cactus (*Opuntia*) pieces.

Procedure—All the three tubes are fitted with corks (above) and capillary tubes (below). Take the different respiratory substrates in the

three tubes ; germinating castor oil seeds in (A), pieces of the cactus in (B) and germinating gram seeds in (C). In (A) the substrate is *fat*, in (B) the substrate is *Organic acid* and in (C) the substrate in *carbohydrate*. The A, B & C shauld be air-tight. The lower ends of the capillary tubes should be dipped in water. Note the initial levels of water in the three capillary tubes respectively and again observe the levels after some time.

Observation—In (A) after some time the level rises. In (B) the level falls down and in (C) there is no change.

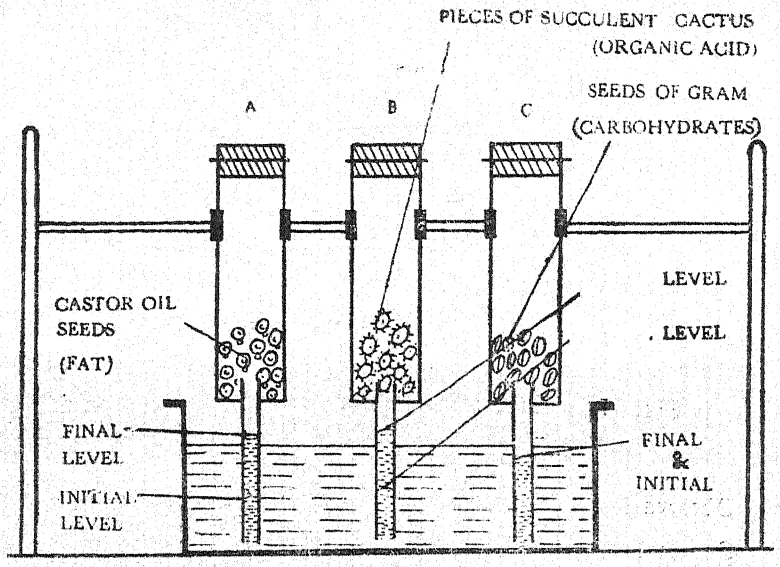


Fig. 175. To compare the value of R. Q. in fatty seeds, carbohydrate and cactus pieces containing organic acids.

Conclusion—In (A) in case of fats, carbon dioxide is leberated in less amount. More amount of oxygen is taken in than amount of carbondioxide liberated. The result is that the water level in the capillary tube rises. The oils and fats are poorer in oxygen than the carbohydrates.

(i) $2\,C_{51}\,H_{98}\,O_6 + 145O_2 = 102\,CO_2 + 98H_2O$

(*Tripalmitin*)

$$\text{R. Q.} = \frac{CO_2 \text{ evolved}}{O_2 \text{ absorbed}} = \frac{102}{145} = 0.7 \text{ (less than unity)}$$

(ii) $C_{57}\,H_{104}\,O_6 + 80\,O_2 = 57\,CO_2 + 52\,H_2O$

(*Triolein*)

$$\text{R. Q.} = \frac{CO_2}{O_2} = \frac{57}{80} = 0.7 \text{ (less than unity)}$$

In (B) where respiratory substrate is organic acid the value of R. Q. is more than unity. Here the water level falls down because in organic acids there is more amount of oxygen. Less amount of oxygen is taken and a large amount of carbondioxide is liberated. The succulent plants show oxidation of organic acids.

(i) $C_4 H_6 O_5 + 3 O_2 = 4 CO_2 + 3 H_2O$

(*Malic acid*)

$$\text{R. Q.} = \frac{CO_2 \text{ given out}}{O_2 \text{ taken in}} = \frac{4}{3} = 1.3 \text{ (more than unity)}$$

(ii) $2 (COOH)_2 + O_2 \rightarrow 4 CO_2 + 2 H_2O + 60.2$ kg. cal.

(*Oxalic acid*)

$$\text{R. Q.} = \frac{CO_2}{O_2} = \frac{4}{1} = 4 \text{ (more than unity)}$$

(iii) $2 C_4 H_6 O_5 + 5 O_2 \rightarrow 8 CO_2 + 6 H_2O$

(*Tartaric acid*)

$$\text{R. Q.} = \frac{CO_2}{O_2} = \frac{8}{5} = 1.6 \text{ (more than unity)}$$

In (C) the respiratory substrate is carbohydrate. Here the value of R. Q. is unity. The amount of oxygen taken in is equal to the amount of carbon dioxide liberated. Thus there is no change in the level of the water in the capillary tube.

$C_6 H_{12} O_6 + 6 O_2 \rightarrow 6 CO_6 + 6 H_2O + 6.3$ kg. cal.

(Glucose)

$$\text{R. Q.} = \frac{CO_2 \text{ evolved}}{O_2 \text{ absorbed}} = \frac{6}{6} = 1 \text{ (Unity)}$$

Precaution

(i) The apparatus should be made air-tight.

(ii) The lower ends of the capillary tubes should be dipped in water.

(iii) The test tube (B) must be covered with a black cloth to prevent photosynthesis.

Modification

Question—What will happen if the water of the trough is replaced by potassium hydroxide solution ?

Answer

(i) In (A) there is less increase in the level.

(ii) In (B) there is maximum increase, and

(iii) In (C) the increase is lesser in comparison to (B).

Reason

Potassium hydroxide has the property of absorbing carbon dioxide. When carbon dioxide is absorbed the levels in the capillary tubes will naturally go up, but the difference is well marked in all the three cases.

EXPERIMRNT 54

Object—To make a comparative study of *photosynthesis* and *respiration.*

Requirements—2 long-necked flasks, 2 small troughs, 2 stands, mercury, caustic potash solution, green leaves, flowers, glass marking pencil, cotton, water etc.

Procedure—Take two long-necked flasks. Fill moistened green leaves in one of them (A) and equal volume of moistened young flowers in the other (B). Plug both the flasks with cotton at the junction of neck and the body of the flasks. Take mercury in two small troughs and keep the two flasks in inverted position on mercury kept in the small troughs and fix the flasks with the help the two stands separately. Keep the experiment in diffuse light and introduce potassium hydroxide solution at evening in both the tubes of the flasks. Observe the rise of the mercury column.

Observation—The flask containing flowers (B) shows higher rise of mercury column than the flask containing green leaves (A).

Conclusion—B records higher rise of mercury column because flowers were only respiring (no photosynthesis due to absence of chlorophyll). The CO_2 (carbon dioxide) evolved in respiration was accumulated.

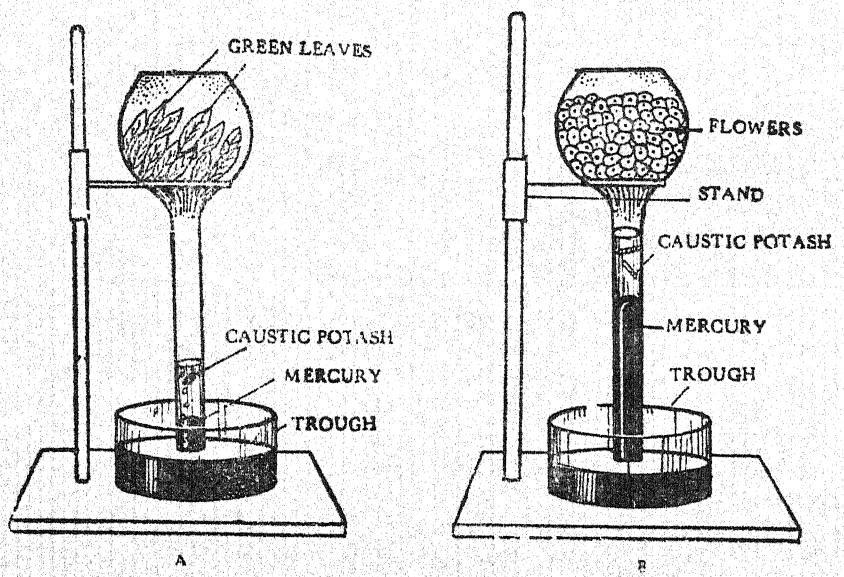


Fig. 176. Showing camparision of respiration and photosynthesis.

This carbon dioxide is absorbed when potassium hydroxide solution is introduced in the tube. This results in the marked rise of mercury column. But in A, carbon dioxide was liberated in respiration and was

consumed in photosynthesis. The fact is that a very little amount of carbon dioxide is left over. This is absorbed when KOH solution is introduced and as the amount of carbon dioxide absorbed is very little, the rise in mercury column is also very little.

Precaution—(i) The apparatus should be air-tight.
(ii) Materials in both the flasks are moistened.
(iii) The flasks are plugged with cotton.
(iv) The experiment is kept in diffuse light.
(v) Potassium hydroxide is introduced at the evening time.

EXPERIMENT 55

Object—To demonstrate the measurement of growth by *Arc auxanometer* (*Lever auxanometer*).

Requirements—Arc auxanometer, potted plant, weight, string, stand, table etc.

Procedure—One end of the cord (thread) is tied to the apex of the stem of the potted plant. Pass the cord over the small wheel (to which an indicator is fixed). Tie a weight at the other end of the cord. Note the position of the arc indicator and after 10 hours observe the movement of the arc indicator along the arc.

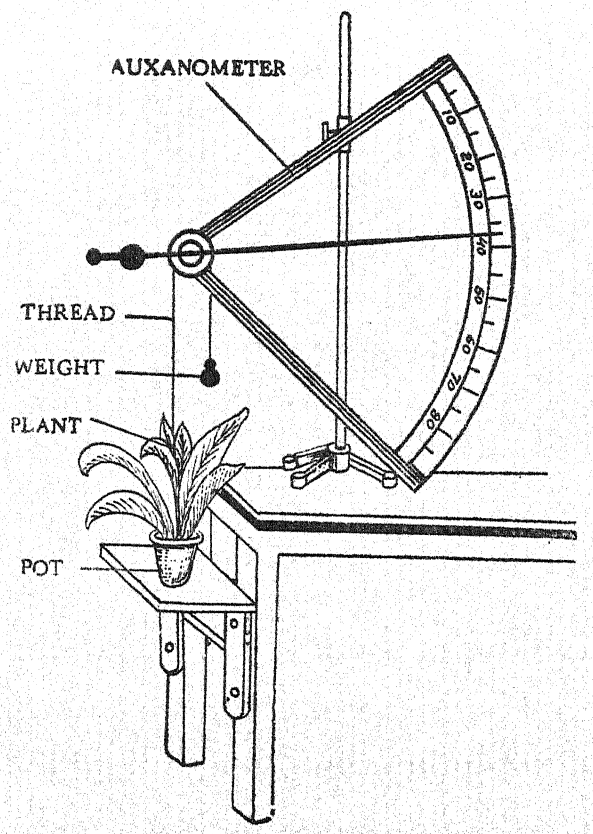


Fig. 177. Showing Arc auxanometer to measure growth.

Conclusion—The indicator moves along the arc scale. This shows that growth has taken place and the stem of the potted plant increases in length. Due to this increase, the wheel slowly moves or rotates as the weight exerts some pressure. This causes the movement of the indicator.

Precaution—(i) The potted plant should be young and in a state of growth.

(ii) The plant should be well watered and should receive open air and light.

Modification

Question—How will you measure the actual growth ?

Answer—First of all the magnification given by the indicator is known. Suppose the diameter of the pully is 4 inches and the length of the needle is 20 inches from the centre of the disc, then magnification of growth shown is 10 times, because ;

$$\text{Magnification} = \frac{\text{Length of the needle}}{\text{Radius of the pulley}}$$

and as the length of the needle is 20 inches and radius of the pulley is 2 inches, now

$$\text{Magnification} = \frac{20 \text{ inches}}{2 \text{ inches}} = 10 \text{ times}$$

Suppose the needle travels 5 cm. in 10 hours then,

$$\text{Actual growth} = \frac{\text{Distance travelled by the pointer}}{\text{Magnification}} = \frac{5 \text{ cm.}}{10} = 0.5 \text{ cm.} = 5 \text{ m.m. in 10 hours}$$

Thus in one hour the needle will travel

$$\frac{5 \text{ m. m.}}{10} = 0.2 \text{ m. m.}$$

Therefore the actual growth is 0.2 m. m. per hour

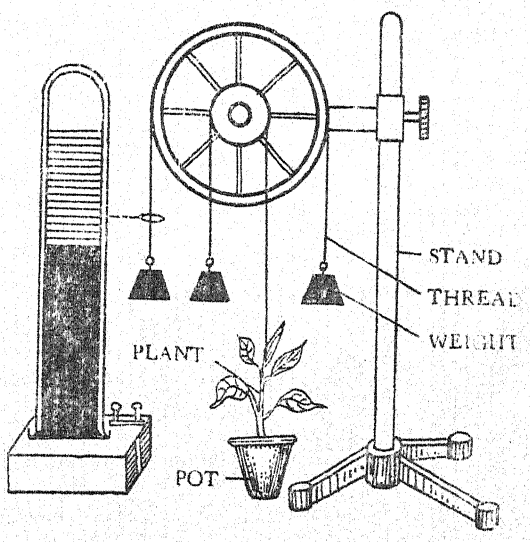
EXPERIMENT 56

Object—To measure growth by *Pfeffer's auxanometer* within a specified time.

Requirements– Pfeffer's auxanometer, potted plant, weights, smoked paper, table etc.

Procedure—One end of the thread is tied to the tip of the stem of the potted plant. The cord is passed over a small wheel which is attached to a large wheel. A weight is tied to the other end of the cord. Another cord is passed over the larger wheel and the two ends of this cord are tied to small weights. A small pointer is attached to the cord passing over the large wheel. A drum is placed close to the pointer and contact is made between the drum and the pointer. The drum is wrapped with a smoked paper. The drum can be rotated by a clock-work mechanism. Rotate the drum and note the impression made by the indicator on the smoked paper.

Observation—The smoked paper shows marks of the moving pointer.



PFEFFER'S AUXANOMETER

Fig. 178. Showing Pfeffer's auxanometer to measure growth.

Conclusion—As the tip of the stem of the potted plant grows, the needle (pointer) moves and leaves marks on the smoked paper wrapped on the drum. If there is no growth, the pointer leaves a straight horizontal line on the smoked paper but if the growth has taken place the pointer leaves a downward spiral mark on the smoked paper. By this method actual rate of growth during a specified period can be calculated by noting the time period of growth and magnification of growth given by drum curve.

Precaution—The smoked paper is dipped in varnish so that smoke is fixed on the paper if a permanent record is to be taken.

EXPERIMENT 57

Object—To demonstrate *seismonastic movement* induced by shocking (stimulation) in *Mimosa pudica* plant.

Requirements—*Mimosa pudica* plant (potted plant).

Procedure—Apply some stimulus (touch) to one of the leaves and observe.

Observation—Most of the leaflets are closed in succession. Finally the main petiole drops down and other leaves too close if the stimulus is strong.

Conclusion—*Mimosa pudica* plant is sensitive to touch, impact, heat and electrical impulses. The plant has compound leaves. A leaf consists of leaf lets. Each leaflet is made up of pinnules. The sequence of closing is important. In case of a stimulated leaf, first the pinnules, then the leaf lets and finally the petiole closes up but in a neighbouring leaf this process is reversed. Here the petiole drops first then the leaflets and finally the pinnu les fold up in pairs.

The reason of this type of movement is that the pinnules are attached to the leaf-rachis and leaflets to the petiole by swollen leaf bases which are known as *pulvini* (singular is *pulvinus*). The cells of the lower half of a *pulvinus* are completely filled with water i. e. they are fully *turgid*. When stimulus is applied, these turgid cells readily lose water, become *flaccid* as the water from these cells moves to the cells of the upper half of the *pulvinus* or intercellular spaces. Thus due to sudden loss of water the pulvinus loses its rigidity and as a result to this the leaf droops downwards.

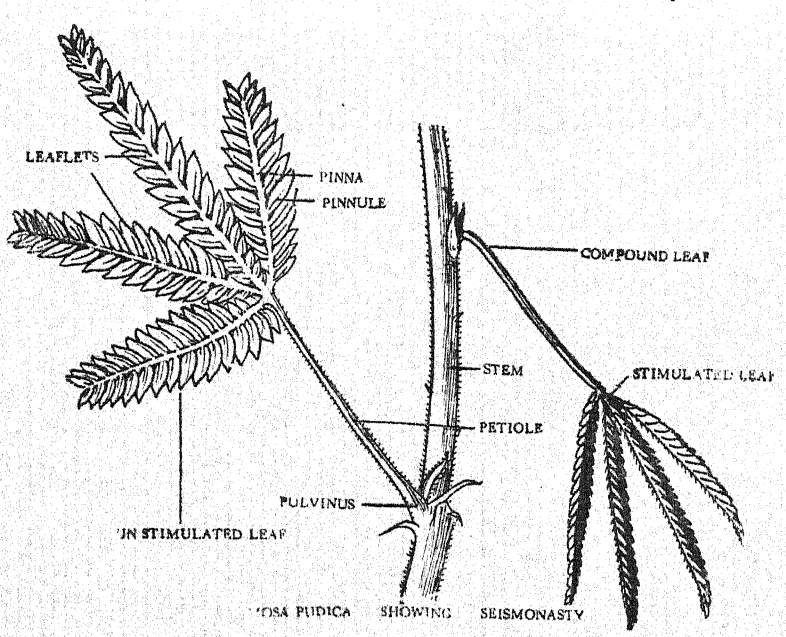


Fig. 179. A twig of the plant of *Mimosa pudica* (Mimosaceae) showing an unstimulated leaf (left) and stimulated leaf (right). The drooping leaf shows *seismonastic* movement.

Precaution—The stimulus should be applied slowly.

EXPERIMENT 58

Object—To demonstrate that stems are *positively phototropic.*

Requirements—A potted plant and a box with a side hole at one side only to provide light.

Procedure—Keep a well watered potted plant inside the box and leave the experiment to remain in sunlight for some time and then observe.

Observation—After some time the stem bends towards the opening through which light is coming.

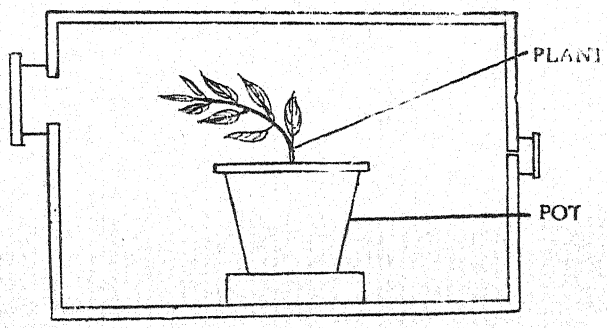


Fig. 180. Showing bending of the stem towards light.

Conclusion—The above observation shows that the stem bends towards light (phototropic movement). This is due to the unequal distribution of hormones on the illuminated and the dark sides of the stem tip. The dark side has more amount of hormone. This causes cell elongation on the dark side resulting into curvature or bending towards illuminated side.

Precaution—There should be only one hole in the box.

EXPERIMENT 59

Object—To demonstrate that the effect of the force of gravity on the plant organs is eliminated by rotation (1—4 per hour) by a *Clinostat.*

Requirements—A young plant with its parts intact, soil and a *Clinostat.*

Procedure—Take the plant and plant it in soil in the pot attached to the clinostat. Keep the plant in horizoatal position. Apply 1—4 rotations per hour and observe the effect of the rotations on the movement of the stem and the root. Keep the experiment in a dark place.

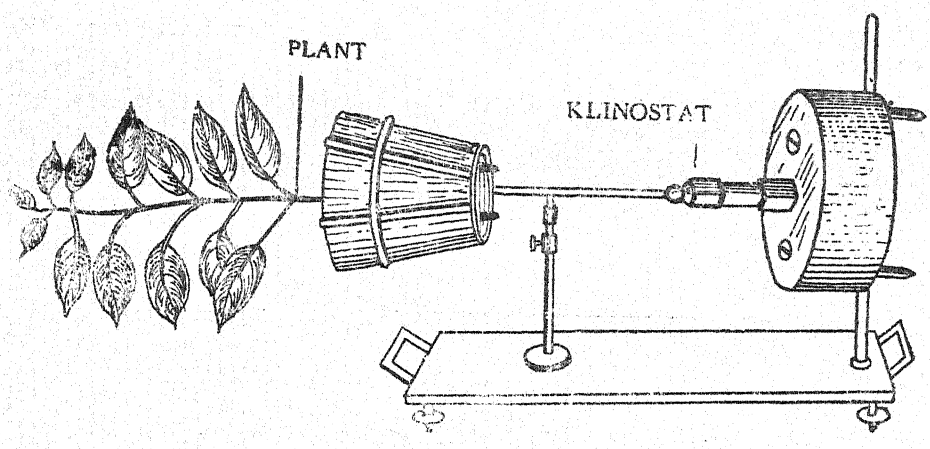


Fig. 181. A Clinostat (with a potted plant) placed in horizontal position to show that the effect of force of gravity on the plant organs is eliminated by rotation (1—4 rotations per hour) of the pot by the clockwork mechanism.

Observation—The plant or its parts do not show any curvature upwards or downwards. It grows straight along as it was placed.

Conclusion—The pot is slowly rotated and each part in turn is exposed to gravity to the same extent. Thus the stem as well as the root grows in the same straight horizontal direction as it was placed. There is no curvature or bending in the stem or the root.

Modification

Question—What will happen if the pot is not rotated ?

Answer—The stem will bend upwarps (away from the force of gravity) and the root down wards (toward the force of gravity). The root shows positive *geotropism* because a particular region of the plant gets more gravitational stimulus than the stem.

Precaution

The experiment is performed in dark so that there is no interference due to light.

CHAPTER 5

Economic Botany

FOOD PLANTS

CEREALS

WHEAT GRAINS (Gehun)

(1) These are the grains of wheat (*Triticum aestivum*) belonging to the family Poaceae (Graminaceae).

(2) The grains are fruits of the type *caryopsis*.

(3) Wheat is a rabi crop and is sown in the months of October—November and harvested in the months of March—June.

(4) The grains are made into flour and then bread (chapatees) are made.

(5) It is the chief food and contains a high percentage of carbohydrate. Protein is also present in it.

(6) The flour is also used for making biscuits, rolls, cakes, macaroni etc.

(7) It is used in the preparation of *beer*.

(8) Wheat bran is an animal feed and straws are used as fodder.

MAIZE GRAINS (Mukka)

(1) These are the grains of corn or maize (*Zea mays*) of the family Poaceae.

(2) The grains (fruits) are of *caryopsis* type.

(3) These are rich in carbohydrate and protein.

(4) It is one of the most important food for man and is used for making bread. Roasted grains are also eaten.

(5) The green and dried plants are used as fodder, corn-flakes and pop-corn are made from the grains. Alcoholic beverages are also made.

(6) The grains are sown in June or July and harvested in October and November.

RICE GRAINS (Chaval)

(1) These are the grains of paddy (*Oryza sativa*) of Poaceae.

(2) The grains (fruits) are of *caryopsis* type.

(3) It is rich in carbohydrate and protein.

(4) Rice is the chief food for half of the world population. Boiled grains are eaten by man. A by product of rice cooking, *mar*, is used by washermen for stiffening cloth. Rice flavour is used in cosmetic industry. Alcoholic breverages are also made.

(5) The grains are sown in June-July and harvested in November-December. The summar crop is sown after December and harvested in May-June. It requires water.

SUGARS

SUGAR CRYSTALS (Chini)

(1) These are the crystals of sugar made from the juice of the stem of the plant called sugar cane (*Saccharum officinarum*) of Graminaceae family.

(2) Sugar cane is the chief source of sugar.

(3) Sugar is used for making sweets and to sweeten a number of edible materials.

(4) Sugar gives energy.

(5) Sugar is also made from chukandar or beet root (*Beta vulgaris*) of the family Chenopodiaceae and khajur or date palm (*Phoenix dactylifera*) of Palmae.

FRUIT OF DATE PALM

(1) It is a fruit of date palm or khajur (*Phoenix dactylifera*) or *P. sylvestris*) of Palmae family.

(2) The fruit is a one seeded *berry*.

(3) The edible part is the *pericarp*.

(4) Sugar is made from the fruits.

STORAGE ROOT OF CHUKANDAR

(1) This is a tuberous or storage root of beet root (*Beta vulgaris*) of the family Chenopodiaceae.

(2) The root is swollen due to accumulation of food.

(3) The root is eaten raw in salad.

(4) Sugar is extract ed from the roots.

PULSES (LEGUMES) & NUTS

PIGEON PEA OR CAJAN PEA (Arhar)

(1) These are the seeds of pigeon pea (*Cajanus indica* syn. *Cajanus cajan*) of the family Papilionaceae (Fabaceae).

(2) The seeds are rich in protein.

(3) It is one of the largely consumed pulses in India. Leaves and pods are fed to cattle. The stalks are used for roofing and also making baskets.

(4) The seeds are sown in the months of May-June and harvesting is done in the months of December-March.

SEEDS OF MATAR (Pea)

(1) These are the seeds of pea (*Pisum sativum*) of Papilionaceae.

(2) The green seeds are tasty and relishing. The seeds are consumed also by livestock.

(3) The green seeds are rich in protein.

(4) It is one of the familiar crops which is grown for pulses. The seeds are also canned and frozen by the canning industry.

(5) The seeds are grown in the months of September-November and is harvested in the months of February-April.

SEEDS OF GRAM (Chana)

(1) These are the seeds of gram or chick pea (*Cicer aeretinum*) of the family Papilionaceae.

(2) The seeds are consumed by both animals and human beings.

(3) The seeds are rich in protein.

(4) Seeds are boiled and cooked as a pulse.

(5) Green seeds are relishing and are used also as vegetable.

(6) Gram flour (besan) is used as a substitute for wheat flour for diabetic patients.

(7) Seeds are sown in early October in Northern India and harvested in February-March.

SEEDS OF SOYBEAN (Bhatt)

(1) These are the seeds of soybean (*Glycine max* syn. *Soja max*) of Papilionaceae.

(2) The seeds are rich in protein (30-45%) and oil (20%). They also contain calcium, iron, and vitamins.

(3) It is consumed fresh, fermented or dried.

(4) Soybean flour is useful for diabetics. Soybean milk is useful for children and invalids. Sauce is also made. Soybean oil is used for cooking and also in many industrial purposes. Nutrinuggets made from soybean are used as vegetable.

(5) The seeds are sown in June or July and harvested in February-March.

FRUITS OF GROUND NUT (Moogphali)

(1) This is a pod of ground nut (*Arachis hypogaea*) of Papilionaceae.

(2) The fruits or pods are *lomentum* (legume).

(3) The fruit contains seeds or kernels which are eaten raw or roasted.

(4) The seeds are rich in protein, oil and vitamins A & B and B_2 group.

(5) The vegetable oil is used for cooking purposes and also for making *hydrogenated vanaspati* (*ghee*), soap etc. Peanut butter is also made.

(6) Sowing is done in the months of April-July and harvested when the crop is fully mature.

CASHEW NUT (Kaju)

(1) It is a 'nut' of cashew nut (*Anacardium occidentale*) of Anacardiaceae).

(2) The fruit is a false fruit and is made up of a swollen peduncle and a disc. The true fruit or the nut is present at the distal end of the false fruit as a small, curved or kidney shaped structure.

(3) The true fruit is roasted and the coats are removed. The inner nut is the edible part of the fruit. It is eaten raw or after they are roasted with salt.

(4) The swollen peduncle after fermentation yields kajuwine. The oil from the shell has many industrial uses.

VEGETABLES

STORAGE ROOT OF CARROT (Gajar)

(1) This is a tuberous storage root of carrot (*Daucas carota*) of Umbelliferae (Apiaceae).

(2) The root is swollen due to accumulation of food material. It is conical tap root.

(3) It is eaten raw or cooked as a vegetable because of the carotene present in abundance.

(4) It is also eaten as salad and 'Gajar ka Halwa' and 'Gajar ka Kanji' is also made from it.

STORAGE ROOT OF RADISH (Mooli)

(1) It is a swollen tap root of radish (*Raphanus sativus*) of Cruciferae.

(2) Due to accumulation of food material the root is swollen.

(3) The stem is reduced and disc like. The radical leaves are in the form of a rosette above the stem. The root is a tap root.

(4) It is the most quickly and easily grown vegetable of the kitchen garden and is fusiform in shape.

(5) The roots are eaten raw or in salad. They are also cooked as a vegetable.

(6) Radish is a good appetizer and helps in digestion and gastric and liver disorders.

STORAGE ROOT OF TURNIP (Shaljam)

(1) It is a swollen storage root of turnip (*Brassica rapa*) of Cruciferae.

(2) The stem is reduced and the root becomes napiform due to accumulation of food.

(3) The root is a tap root.

(4) Roots are cooked as vegetables.

(5) Leaves are used for salad and for forage and manuring.

STORAGE ROOT OF CHUKANDAR

(1) It is a modified tap root of beet (*Beta vulgaris*) of Chenopodiaceae.

(2) The stem is reduced and the root is swollen due to accumulation of food.

(3) It is eaten raw or in salad or cooked as a vegetable.

(4) The leaves are used in salad or fed to cattle.

(5) It is a good source of sugar. The suger beet industry is competing successfully with sugar cane industry.

STORAGE ROOT OF SWEET POTATO (Shakarkandi)

(1) This is a root tuber of sweet potato (*Ipomoea batatus*) of the family Convolvulaceae.

(2) The root is swollen due to accumulation of food. The roots are adventitious roots and their tips swell up in the form of large tubers.

(3) It is rich in starch (18%) and carbohydrates (8%) and also contains protein, iron, calcium and vitamins.

(4) It is eaten after cooking (boiling or roasting) and also used as a vegetable.

(5) The green tops are fed to animals.

(6) Fermented sweet potato produces alcohol.

STEM TUBER OF POTATO (Alu)

(1) It is a tuber of potato (*Solanum tuberosum*) of Solanaceae family.

(2) It is a modified underground stem which becomes swollen and tuberous due to accumulation of food (starch) at the tip of the underground branches of the stem.

(3) The tuber bears a number of '*eyes*' which are groups of buds growing in the axils of aborted leaves.

(4) Each eye has a central bud surrounded by smaller lateral buds.

(5) The crop is propagated by the tuber pieces. Each piece should have atleast one '*eye*'.

(6) The tubers are eaten after cooking as a vegetable. Chips and papad are also made.

(7) Tubers are rich in carbohydrates (19%), protein (2%) and fat (1%) are also present in it. Fresh tubers are important source of vitamins B & C. Alcolhol is also prepared.

BULB OF ONION (Pyaj)

(1) It is a bulb of onion (*Allium cepa*) of Liliaceae.

(2) The stem is reduced and disk-shaped. It bears a number concentric leaves and fibrous roots.

(3) The leaves store food material and constitute the main part of the bulb.

(4) The bulbs are used for vegetative propagation of the plant.

(5) The fleshy leaves are rich in sugar. They are eaten raw, in salad or cooked as a vegetable.

(6) The pungent flavour is due to persence of an acrid volatile oil, allyl sulphide.

(7) Onion has medicial properties. It is antibacterial. It helps in digestion.

BULB OF GARLIC (Lahsun)

(1) It is a bulb of garlic (*Allium sativum*) of Liliaceae.

(2) The Stem is reduced. The leaves store food material. Roots are fibrous. The leaves constitute the main part of the bulb.

(3) It is eaten raw, in salad or used in vegetables.

(4) It is a very good flavouring material (for vegetables).

(5) It has a number of medicinal properties. It helps in digestion, gastic disorder, blood pressure and even heart trouble.

(6) The punjent smell is disagreeable to many persons. Now it is available in the market in the form of capsules under the commercial name *'LASONA'*.

FRUIT OF TOMATO (Tamatar)

(1) It is a fruit of tomato (*Lycopersicum esculentum*) of the family Solanaceae.

(2) The fruit is a *berry*.

(3) The fruit contains a large amount of water; sugars, acids and vitamins are also present. It is rich in vitamin C.

(4) The fruits are eaten as raw, in salad or as a vegetable.
(5) Tomato sauce is prepared from the fruit juice.
(6) Tomatoes are also consumed by animals.
(7) Tomato seeds are the source of an antibiotic, *tomatine*.

FRUITS

FRUIT OF APPLE (Seb)

(1) It is a fruit of apple (*Pyrus malus*) of Rosaceae.
(2) The fruit is *pome* or *false fruit*.
(3) The edible part is the thalamus which is fleshy and surrounds the true fruit.
(4) The fruits are rich in sugar (11%). It also contains protein, fat, fibre and acids.
(5) The fruits are eaten raw or used in the form of fruit juice stored in bottles (canned).
(6) Jams and jellies are prepared from the fruits. Alcoholic products are also prepared from it.

CLUSTER OF GRAPES (Angoor)

(1) It is a cluster or bunch of fruits of grape (*Vitis vinifera*) of Vitaceae family.

(2) The fruits are *berries*.
(3) The fruits have very high sugar content.
(4) Raw fruits are eaten because of the sweet and relishing taste.
(5) Good quality of wine an brandly are prepared from the juice of the berries.

(6) Grape fruits are dried to make raisins and currants.
(7) Jams and jellies are olso prepared from grapes.

FRUIT OF MANGO (Aam)

(1) It is a fruit of mango (*Mangifera indica*) of the family Anacardiaceae.
(2) The fruit is a fleshy drupe.
(3) The edible part is the pulpy mesocarp.
(4) Ripe fruit juice is sweet and relishing.
(5) Pickles, chutney and sauces are made from it.
(6) Dried juice is made into thick layers called *'amawat'*. Jams and jellies are also made from it. Dried powder called *'amchur'* is used with spices for cooking vegetables.

FRUIT OF LEMON (Nimboo)

(1) It is a fruit of lemon (*Citrus limon*) of the family Rutaceae.
(2) The fruit is a *hesperidium*.
(3) The edible part is the placental hairs which are juicy.
(4) Fruit contains sugar, citric acid and vitamin C.
(5) Oil is used in medicine, in the perfume and soap industries, and for flavouring.

FRUIT OF ORANGE (Santara)

(1) It is a fruit of orange (*Citrus reticulata*) of Rutaceae.
(2) The fruit is a *hesperidium*.
(3) Placental hars are juicy and are edible.
(4) The juice is sweet in taste and is relished. Orange juice is a popular drink. Juice is also canned. It contains sugar, acids and vitamin C.
(5) It is used for flavouring.
[Narangi is *C. aurantium*].

FRUIT OF BANANA (Kela)

(1) It is a fruit of banana (*Musa paradisiaca* sub-sp. *sapientum*) of Musaceae.
(2) The fruit is seedless *berry* and the fruits are formed in clusters.
(3) The edible part is the pulp. The ripe fruit is eaten raw.
(4) It contains plenty of carbohydrates. It also contains fat, protein, minerals and vitamins.
(5) Unripe fruits are used as a vegetable. It is also fed to cattles.
(6) Banana flour is used in the preparation of soap.
(7) It is a flavouring material.

FRUIT OF GUAVA (Amrood)

(1) It is a fruit of guava (*Psidium guajava*) of the family Myrtaceae.
(2) The fruit is a berry.
(3) The whole fruit is eaten when ripe. It is a sweet, juicy and flavoured fruit.
(4) The fruit contains sugar, pectin, vitamins A, B & C and ascorbic acid.
(5) It is eaten raw or as jams and jellies.
(6) It is also a flavouring material.

FRUIT OF PINEAPPLE (Ananas)

(1) It is a fruit of pineapple (*Ananas comosus*) of the faimly Bromeliaceae.
(2) The fruit is a large multiple *sorosis* and formed by fusion of all parts of the inflorescence.
(3) The fruit contains sugar, acids, vitamins and minerals. It also contains a digstive enzyme, *bromelin*.
(4) The fruit is eaten (when ripe), or the juice is extracted. Pineapple juice is a delicious drink.

(5) It is also used in beverages.

(6) The fruit "*shells*", a waste product of the canning industry, are fed to cattles.

(7) A flavouring material is extracted from it.

FRUIT OF PAPAYA (Papita)

(1) It is a fruit of papaya (*Carica papaya*) of the faimly Caricaceae.
(2) The fruit is a *berry*.
(3) The yellowish orange pulps of the ripe fruits are eaten fresh.
(4) Pickles, jellies and juice are prepared from it.
(5) Unripe fruits are used for vegetables.
(6) It yields a *latex* which is used in the manufacture of chewing gum.

(7) It contains a digestive enzyme *papain*. Pieces of green papaya are used to soften meat during cooking.

(8) It is also used in the manufacture of cosmetics.

FRUIT OF LITCHI

(1) It is a fruit of litchi (*Litchi chinensis* Syn. *Nephelium litchi*) of the family Sapindaceae.

(2) The fruit is a one seeded nut.

(3) Fruits are produced in clusters during summer season. They are round or oblong.

(4) The seed is surrounded by a fleshy whitish flesh and is edible.
(5) The flesh of the fruit is juicy and is eaten raw.

SPICES AND FLAVOURING MATERIALS

CORIANDER (Dhania)

(1) These are the dried fruits of coriander (*Coriandrum sativum*) of Umbelliferae.

(2) It has highly pleasant aromatic smell and is used as a spices.

(3) The fruits are globular, yellow-brown in colour and does not easily break up into the two mericarps.

(4) It contains about 1% essential oil and 10-20% fixed oil.

(5) The fruits are used in preparation of sugar candies. Coriander oil is used in flavouring wisky, gin and other liquors.

(6) It has also some medicinal properties.

CUMIN (Jeera)

(1) These are the frints of cumin (*Cumimum cyminum*) of Umbelliferae.

(2) The fruits are elongated and oval. The mericarps are hairy and narrow ridged and are separated easily.

(3) They contain 4% essential oil and about 10% fixed oil.
(4) It is used in soup, cake, biscuits, pickles, vegetables etc.
(5) It is used with ghee to flavour the '*dal*'.
(6) It has also some medicinal properties.

CARDAMOM (Illaychi)

(1) These are the fruits of cardamom (*Elettaria cardamomum*) of the family Zingiberaceae.

(2) The fruits (capsules) are light brown in colour and roughly triangular in shape. The fruit wall is papery and inside there are a number of seeds.

(3) The seeds are dark-grey to black in colour and contain starch and 4-7% volatile oil.

(4) The seeds are aromatic and highly flavoured.
(5) Used for flavouring curries, cakes, biscuits, pickles, sweet dishes etc.
(6) They have medicinal properties and are used as carminatives.
(7) Cardamom oil is also used for flavouring.

FENNEL (Saunf)

(1) These are fruits of fennel (*Foeniculum vulgare*) of Umbelliferae.

(2) The fruits are oval and green or yellow-brown. The fruit wall has five ridges.

(3) The fruit contains 12-18% oil (semi-drying) and upto 6% volatile oil.

(4) The volatile oil is used for scenting soaps.

(5) Semi-drying oil is used as a carminative, flavouring material and in the manufacture of soap.

MUSTARD (Sarsoan)

(1) These are the seeds of mustard (*Brassica campestris*) of Cruciferae.
(2) The seeds are an important spice.
(3) The seeds contain a fixed oil, and a glucoside, *sinalbin* or *sinigrin*.
(4) The glucoside is responsible for sharp taste and pungent smell.

(5) Mustard oil is a cooking oil. It is also used in preparing pickles, sardines, salad etc.

PEPPER (Kali Mirch)

(1) These are the dried fruits of pepper (*Piper nigrum*) of the family Piperacea.

(2) The dried fruits (peppercorns) are wrinkled and black coloured.
(3) The fruits are aromatic and pungent.
(4) It contains volatile oil, oleoresin and alkaloid.

(5) Pepper is the most important spice. It is used as a condiment and flavouring material for a number of food stuffs.

(6) Pepper helps in the digestion of food by stimulating the flow of saliva and gastric juices.

CHILLIES (Lal & Hari Mirch)

(1) The fruits of chillies (*Capsicum sp.*) belong to the family Solanaceae.

(2) The fruits are many seeded large fleshy berries.
(3) The unripe fruits are green in colour but become red when ripe.

(4) The fruits are pungent due to the presence of a volatile compound called *capsaicin*. They also contain vitamins C, A & E.

(5) Both green and ripe fruits are used as a spice. It is also used for flavouring and colouring vegetables and non-vegetarian preparations.

(6) It is used in pickles and some of the beverages because of its pungency.

CLOVES (Laung)

(1) These are dried unopend flower buds of *Eugenia aromatica* (Myrtaceae).

(2) The ovary matures into a cylindrical one seceded drupe.

(3) Cloves are highly aromatic with a fine flavour.

(4) It is used for flavouring a number of vegetarian and non-vegetarian preparations like curries, pickles, sauces and ketchup.

(5) Clove oil is extracted from the flower buds. The oil is used in toothaches, in perfumery, in soap, as clearing agent and in tooth pastes etc.

(6) It is used in betel or as such after meals.

SAFFRON (Kesar)

(1) It is obtained from the flowers of kesar plant, *Crocus sativus*, belonging to the family Iridaceae.

(2) The deried stigmas and style tips are the source of saffron.

(3) It is the most costly spice in the world.

(4) It is a flavouring material and used in perfumery.

(5) It has some medicinal properties and is effective in relieving cold and cough.

(6) It is chiefly used as a dyestuff.

CINNAMON (Dalchini)

(1) It is the bark of the tree called *Cinnamomum zeylanicum* of the family Lauraceae.

(2) It is used as a spice for flavouring vegetables, meat, sweet and other food stuffs.

(3) Cinnamon oil has some medicinal properties. It is used as a carminative, antiseptic, and stringent.

(4) It is a constituent of curry powder.

(5) It has aromatic smell.

TURMERIC (Haldi)

(1) It is a modified underground stem (*rhizome*) of turmeric (*Curcuma longa*) of the family Zingiberaceae.

(2) It is swollen due to accumulation of food.

(3) Nodes and internodes are well marked.

(4) It is highly aromatic and has musky taste and odour.

(S) It is an important spice used in vegetables and '*dal*' and is an important flavouring agent.

(6) It produces a yellow-orange dye. It is used in colouring pickles, mustard, butter, cheese etc.

(J) It has some medicinal properties and is used to relieve pains.

(8) It is thought to be very sacred by the Hindus and is used on religious and ceremonial ocacsions.

GINGER (Adrak)

(1) It is an underground modified stem of ginger (*Zingiber officinale*) of Zingiberaceae.

(2) The stem is a *rhizome* with distinct nodes and internodes.
(3) It is swollen due to accumulation of food material.
(4) It contains starch, gums, oleoresin and an essential oil.

(5) The essential oil gives the aromatic smell and *gingerin* gives the pungent taste.

(6) It gives a feeling of warmth by dilating the blood vessels. It also helps in lowering the body temperature.

(7) It is used in the preparation of pickles, curries beverages etc.
(8) It is effective in digestive diorders.
(9) Distilled ginger oil is used in perfumery.

BEVERAGE PLANTS AND BEVERAGES

TEA (Non-alcoholic Beverage)

(1) These are dried and processed tea leaves (*Camellia sinensis*) of the family Theaceae.

(2) It is the most popular non-alcoholic drink.

(3) Usually the bud is plucked alongwith the first and the second leaves.

(4) In bud 25% tanin is present and in the first leaf it is 28% while in the second leaf it is 21%. Thus the quality of tea is excellent when bud and the first leaf is plucked for making tea.

(5) Tea contains an alkaloid, *theine* 2-5%), a volatile oil and 14-28% tanin.

(6) *Theine* and the volatile oil dissolve quickly in hot water and are responsible for giving refreshing and stimulating drink.

(7) Tea relieves body fatigue but too much tea drinking is harmful for digestive system.

COFFEE (Non-alcoholic Beverage)

(1) Like tea, it is also the most popular non-alcoholic drink of the world.

(2) Coffee is made from the seeds of coffee plant (*Coffeea arabica*) of Rubiaceae. It is known as Arabian Coffee. *C. robusta* (Congo Coffee) and *C. liberica* (Liberian Coffee) are also useful.

(3) The fruits are two-seeded or one-seeded drupes.

(4) The leaves and the fruits contain 1-2% caffein. The green seed contains 34% cullulose, 8% chlorogenic acid, 10-13% oil, 7% sugar, 14% protein, 12% water etc.

(5) It relives fatigue and is a stimulant.

(6) It is used with profit in curing blood pressure and digestive disorders.

(7) They are also used for the manufacture of cafelite (a plastic material) used for insulating purposes.
(8) The waste products are used as fertilizer and fuel.

COCOA & CAOCOLATE (Non-alcoholic Beverage)

(1) Cocoa and chocolate are derived from the seeds of the cacao tree (*Theobroma cacao*) of the family Sterculiaceae. These are the most nutritious of all beverages.

(2) 50-60 'beans' are present in one pod like fruit.
(3) The fruits or pods are directly borne on the trunks.
(4) The seeds contain fats, proteins and carbohydrates.
(5) Cocoa butter is an edible fat.

(6) It yields an alkaloid *theobromine* used in the soft drinks like 'colas'.

(7) The cocoa shells are used as cattle feed and fertilizer.

WINE (Alcoholic Beverage)

(1) Wine is a *fermented beverage.*

(2) It is prepared by fermenting juice of grapes (berries or fruits) of grape plant(*Vitis vinifera*) of the family Vitaceae.

(3) The sugar present in the juice of grape berries is converted into alcohol by the yeast (*Saccharomyces cerevisiae*) and the fermentation is brought about by the two *enzymes, Invertase* and *Zymase.* A preservative dose of sulphur dioxide is also added. The process of fermentation takes 7 days. Then it is filtered and clarifying agent is added to get clear wine. It is stored in wooden vessels for aging. After six months the wine is ready for use.

(4) In measured quantity wine is good but excessive drinking is very dangerous.

(5) *Beer, Hard Cider, Root Beer, Mead, Sake, Palm Wine, Pulque* and *Chicha* are all fermented beverages.

(5) Any fruit having proper sugar-acid ratio and a fruity flavour can be used for making wine. Thus there are a number of varieties and colours of wines.

BEER (Alcoholic Beverage)

(1) Beer is a fermented beverage.
(2) It is prepared from barley (*Hordeum vulgare*), rice (*Oryza sativa*) maize (*Zea mays*) etc. of the family Graminaceae.

(3) First the starch is converted into sugar (*malting*) and then fermenting them (*brewing*).

(4) Beer contains 3-8% alcohol, sugars, dextrin, phosphates and proteins.

WHISKY (Alcoholic Beverage)

(1) It is a distilled beverage.

(2) Malted or unmalted cereals or potatoes are fermented to give a mash which is distilled several times. This yields 'high wine'.

(3) High wine when mixed with water is known as whisky.

(4) *Scotch whisky* is prepared from barley, *Vodka* from wheat, *Rum* from sugar-can juice and molasses and *Gin* from barley or rye.

FIBERS

JUTE (Soft or Bast Fiber)

(1) It is obtained from jute plant (*Corchorus capsularis* or *C. olitorius*) of the family Tiliaceae.

(2) The jute fiber develops in the outer portion of the bast (*secondary phloem*) of the stem. The retted strands of jute are 5 to 10 feet in length.

(3) The fibres of *Corchorus capsularis* are whitish and are called 'white jute' and are superior to the fibers of *C. olitorius*.

(4) The fibers of jute are cheap and are readily spun. Coarse sacs, bagas, canvases, gunny bags, curtains, roofing fabrics and covers for cotton bales and bags for packing of sugar, potato, onion, pulses etc. are made from jute fibers.

(5) Ropes are also made from it.

FLAX (Alsi or Tisi)

(1) The soft fibers are obtained from the stem of flax (*Linum usitatissimum*) which belongs to the family Linaceae.

(2) The fibers of flax occur in the *pericycle* and are tough, flexible, strong, long, durable and lustrous. The cell wall contains 90% cellulose.

(3) The fiber is spun into quality yarn and are used in the manufacture of linen cloth and thread.

(4) The threads are strong and are used for tailoring, shoe making, nets etc.

(5) The fiber is used in making convases, carpets, cigarette paper, writing paper etc.

(6) Coarse fabrics and ropes are also made from it.

HEMP (Bhang)

(1) The fibers of hemp are obtained from the stem of hemp plant (*Cannabis sativa*) of Cannabinaceae family.

(2) The fibers occur in the *pericycle*.

(3) The fibers are white or dark brown in colour and are much longer (3-15 ft.) than the flax fibres. They are strong, durable, flexible and the cell wall contains 80% cellulose. The fibers are unaffected by water.

(4) The fibers are used in the manufacture of ropes and twines.

(5) Carpets, bags, binder twine etc. are made from the fibers.

(6) Cheap and coarse cloth is also mode from the fibers.

[Soft fibres are also obtained from sunn hemp (*Crotolaria juncea*) of Malvaceae.]

COTTON OR KAPAS (Surface Fiber)

(1) Cotton fibers are obtained from *Gossy-pium herbaceum* (Malvaceae). Some other species of *Gossypium*, also produce fibers e. g. *G. hirsutum*, *G. arboreum* and *G. barbadense*.

(2) The cotton fruit is a capsule. The fruits are called "*bolls*". Each friut has three to five locules called "*locks*". Fibrous seeds are present inside the locks. A *boll* may contain 24-50 seeds.

(3) Each seed is ovoid, pointed at one end and is dark brown is colour.

(4) A large number of tubular out growths or hairs arise from the epidermal surface of the seed coat.

(5) Longer hairs are known as *'lint'* and shorter hairs are called *'fuzz'*.

(6) Hairs are twisted and the twists enable the fibers to be spun into yarn and it also helps in the coherence of the individual fibers.

(7) Cotton fibers are made into thread and cloth.

(8) Absorbent cotton (cleaned fibers) are almost pure cellulose and are used in cellulose industries.

(9) It is used in the manufacture of rubber-tier fabrics, in plastic reinforcing, carpeting etc.

(10) Unspun cotton is commonly used for stuffing purposes e. g. pads, pillows, cushions etc.

COCONUT OR COIR (Surface Fiber)

(1) It is obtained from the coconut plant (*Cocos nucifera*) of the family Palmaceae (Palmae).

(2) The fruit is a one seeded *drupe*. Fruits are produced in clusters at the top of the plant. They are three angled and the colour ranges from darkgreen to deep orange or brick red.

(3) The exocarp and mesocarp are thick and fibrous. This is the source of coir. Ths endocarp is hard and stony. It bears pores at one end and the embryo lies below one of these pores.

(4) Internally there is a thick albuninous endosperm (meat or *gari*) attached to the endocarp.

(5) The endocarp encloses a large cavity filled with a watery fluid. It is nutritious and is called *'coconut milk'*.

(6) The husk is the source of the fiber-coir which is used for stuffing purposes.

(7) Coconut oil (obtained from the endosperm) is a fatty oil. It is used for cooking, soap making, as hair oil, shampoos, shaving cream, cosmetics etc.

(8) The oil is also used as a lubricant. It is also used as fuel.

(9) The fresh *"meat"* (endosperm) is eaten raw or dried and is also used in making sweets .

(10) The delicious coconut milk is a refreshing drink.

[The fibers obtained from semal plant (*Salmalia malabarica*) of Bombacaceae and Madar (*Calotropis gigantia*) of Asclepiadaceae are also used for stuffing purposes.]

WOOD AND CORK

PAPER

(1) Papers are manufactured from natural fibrous materials like wood fibres, cotton and linen.

(2) Cellulose in the pure form gives very good quality of paper.

(3) Cotton (*Gossypium sp.*) has 91% cellulose.

(4) Linen or flax fiber (*Linum usitatissimum*) has 82% cellulose.

(5) Wood pulp (long and strong cellulose fibers) is derived from the the spp. of spruces (*Picea*), pines (*Pinus*), aspens (*Populus*), balsam fir (*Abes balsamea*), sugar maple (*Acer saccharum*) and birch (*Betula lutea*).

(6) Some other plants are : bamboo (*Bambusa sp.*), paper mulbarry papyrus (*Cyperus papyrus*) and stems of members of the grass family.

(7) Paper is used for writing and printing purposes. The other types of the paper are : wrapping paper, blotting paper, packing paper (vegetable parchment), carbon paper, cigarette paper, roofing and building paper and facial tissue paper.

(8) The poor-grade papers contain resins and lignin etc. and turn yellow due to the presence of these substances.

CORK

(1) Cork is obtalnad from the bark of trees,

(2) The most important plant is cork oak (*Quercus suber*) whi ch belongs to the family Fagaceae.

(3) The cork is formed by the activity of cork cambium ring.

(4) The cells of the cork are thick walled suberised cells, the cell walls having deposition of waxy suberin.

(5) The cork pieces are dried in open, seamed or boiled to remove the sap and tannis and also to increase the volume and elasticity.

(6) Cork is used as bottle corks of stoppers, in the manufacture of insulating board, hats, life jackets, mats and in sound proofing of the rooms.

RUBBER

(1) Rubber is obtained from the Hevea or Para rubber tree (*Hevea brasiliensis*) which belongs to the family Euphorbiaceae.

(2) The *latex* of *Hevea* contains 30% dry rubber.

(3) Latex is obtained from the latex vessels of the bark by cutting the bark in such a manner that the cambium is not damaged.

(4) The latex is collected and processed to get rubber. It is white in colour and is an emulsion.

(5) Chemically rubber is an amorphous hydrocarbon of *polyterpenes* group.

(6) Rubber has many uses. It is used mainly for tyers and tubes of motor car, trucks, jeeps, scooters, cycles etc. In hard form it is used in surgicals, radio and telephone parts. It is also used in road construction and in making shoes; water proof clothes, insulated wire and a number of electrical goods.

[Note : Rubber is also obtained from Assam rubber (*Ficus elastica*) of Moraceae, Panama or Castilla rubber (*Castilla elastica*) of Moraceae, Ceara or Manicoba rubber (*Manihot*) of Euphorbiaceae etc.]

GUMS

GUM ARABIC (Babool)

(1) It is obtained from *Acacia senegal* syn. *A. arabica* (Leguminosae).

(2) The hardened exudates are collected after making incisions in the bark of the tree.

(3) It is translucent, odourless and tasteless and is soluble in water. Gum is rich in sugar and is similar to pectins.

(4) The gum is used as adhesive, in printing, paints, medicines, polishes inks, sizing of paper etc.

GUM TRAGACANTH

(1) It is obtained from *Astrgalus gummifer* (Leguminosae).

(2) The exudates are collected after making incisions in the bark.

(3) It is formed from the pith and medullary ray cells of the lower trunk or roots.

(4) It is opaque.

(5) The gum is used an adhesive, in Calico printing and in medicines.

KARAYA GUM OR INDIA GUM

(1) It is obtained from a Central Indian Plant, *Sterculia urens* of the family Sterculiaceae.

(2) Heartwood is the source of this gum and large incisions are made into the heart wood for this gum.

(3) The gum is very cheap.

(4) It is used in cosmetics, cigar, paste, food industries, textiles and food industries.

FATS AND OILS

COCONUT (Nariyal)

(1) Coconut palm is a source of vegetable fat.

(2) It is obtained from the coconut palm (*Cocos nucifera*) of the family Palmaceae.

(3) Oil is extracted from the albuminous endosperm ('meat') attached all over the endocarp. The dired 'meat' is called copra. Oil is obtained by crushing the copra.

(4) Coconut oil is pale yellow or colourless.

(5) It is widely used as fatty oil and refined oil is used in various food products.

(6) It is also used as a hair oil, in manufacture of soaps, shampoos, shaving creams, cosmetics, as fuel, lubricant etc.

(7) The meat (endoeperm) or kacchi gari is also eaten raw and is used in preparing sweets.

LINSEED (Flax or Alsi)

(1) Linseed oil is a drying oil.

(2) It is obtained from the linseed plant (*Linum usitatissimum*) of the family Linaceae.

(3) The oil is obtained from the seeds which contain 32-43% oil.

(4) The predominant component of the oil are ***linolenic, oleic*** and ***linolic acids.***

(5) The linseed oil is yellow-brown in colour.

(6) The refined (unheated) oil is used in cooking and also as fuel and in leather industry.

SAFFLOWER

(1) Safflower oil is a drying oil.

(2) The oil is obtained from the seeds of safflower (*Carthamus tinctorius*) which belongs to the family Compositae (Asteraceae).

(3) The seed is an achene and contains 24-36% oil.

(4) The oil is mainly used for cooking purposes.

(5) The oil is also used in paints and varnishes.

SESAME (Til)

(1) It is a semi-drying oil.

(2) The oil is obtained from sesame (*Sesamum indicum* syn. *S. orientale*) of Pedaliaceae family.

(3) The oil is obtained from the seeds which are white, brown or black in colour.

(4) The seeds contain 50% oil (*oleic* and *linolic glycerides*), 18—25% carbohydrates and 20—25% protein.

(5) It is used for cooking.

(6) It is hydrogenated to produce vegetable "*ghee*".

(7) The inferior quality of oil is used in soap, perfumery, hair oil and paints.

(8) The oil is also used in medicines.

SUNFLOWER (Suryamukhi)

(1) It is also a semi-drying oil.

(2) The oil is obtained from the seeds of sunflower (*Helianthus annus*) of Compositae (Asteraceae).

(3) The seeds contain 55-60% *linoleic acid* and 25-30 % *oleic acid*. Semidrying oil is 32-45%.

(4) The oil is pale yellow in colour and the sunflower oil meal contains 40% protein of high quality.

(5) The oil is used for cooking purposes.

(6) It is used in margarines and manufacture of butter substitutes.

(7) The oil is also used in the manufacture of paints, varnishes, soaps and cosmetics.

MUSTRAD (Sarsoan)

(1) Mustard oil is midway between demi-drying and non-drying oils.

(2) The oil is obtained from the seeds of yellow sarsoan (*Brassica campestris* var. *sarsoan*), black sarsoan (*B. campestris* var. *toria*) or rai (*B. juncea*) of the family Cruciferae.

(3) The seeds are small, round and yellow or black in colour.

(4) The seeds contain 30—45% oil. The oils contains *glycerides* of *erucic*, *oleic* and *linolic acids*.

(5) The crude oil is yellow, light brown or greenish in colour and has a sharp taste and pungent smell.

(6) The oil is edible and is the chief medium for cooking vegetables.

(7) The oil is used as a fuel in lamps.

(8) It is used in the manufacture of soap, as lubricant, for massaging body, as hair oil and in medicines.

(9) The oil cake ('khali') is nutritious and is a very good cattle feed.

[Note—Recently oil obtained from the seeds of the rape (*Brassica napus*) of Cruciferae is being used as a substitute for mustard oil.]

CASTOR (Arandi or Reri)

(1) It is a non-drying oil.

(2) It is obtained from the seeds of castor (*Ricinus communis*) which belongs to the family Euphorbiaceae.

(3) The fruits contain large mottled seeds and the seeds contain 35-55% oil.

(4) The oil is thick, colourless or greenish.

(5) The oil has medicinal properties. It is a purgative.

(6) It is used in the manufacture of soaps, inks, plastics, leather, paints, linoleum, oil cloth, nylon etc.

(7) It is also used as a fuel in lamps.

(8) The oil cake is a very good fertilizer though poisonous.

ESSENTIAL OILS

ROSE OIL (Attar of Roses)

(1) It is a perfume oil.

(2) It is obtained from flowers (petals) of damask rose (*Rosa damascena*) which belongs to the family Rosaceae.

(3) It is used in face powders or cosmetics.

(4) It is rubbed on the cloth in very small amounts for it has soothing smell.

LAVENDER

(1) It is a perfume oil.

(2) It is obtained from the flowers of *Lavandula officinalis* of Libiatae (Lamiaceae) family.

(3) It is used in a number of cosmetics for its fragrance.

(4) It has cooling or soothing effects and is used in high fever. A few drops are added in water and piece of cloth dipped in this water is kept on the forehead for lowering down the temperature and to get relief from head-ache.

MEDICINAL & INDUSTRIAL OILS

CAMPHOR

(1) Camphor oil is liquid at higher temperatuers but on cooling solid camphor is obtained.

(2) Comphor is obtained from camphor tree (*Cinnamomum camphora*) of the family Lauraceae.

(3) The wood, twigs and leaves are macerated and distilled with steam to obtain oil.

(4) The oil is cooled and purified for colourless crystalline camphor.

(5) It has a sharp odour and pungent and aromatic smell. It is volatile and thus kept with dried flower buds of clove (laung).

(6) It is used in the production of celluloid and has also medicinal value.

(7) In India it is burnt before the dieties of gods and in religious functions.

CLOVE (Laung)

(1) Clove oil is obtained from the flower buds and stems of *Eugenia aromatica* syn. *Syzygium aromatica* of Myrtaceae family.

(2) The dried unopened flower buds are used in spices.

(3) The oil is highy aromatic and has a fine flavour.

(4) The oil is prepared by distillation of flower buds, stems or fruits. It contains *eugenol*.

(5) It is used as an antiseptic and for the relief of toothaches.

(6) The oil has many other uses. It is used in perfumery, in soap, in histological work (by students and research workers in biology) as a clearing agent and is also used in tooth pastes.

PEPPERMINT

(1) It is obtained from some species of *Mentha* plant *i. e. M. piperata* of Labiatae (Lamiaceae) family.

(2) The oil contains *methanol*.

(3) It is used in chewing gums, sweets, tooth pastes etc.

(4) It has antiseptic properties and is useful in digestive disorders.

AJOWAN

(1) It is obtained from the seeds of *Trachyspermum copticum* of the family Umbelliferae (Apiaceae).

(2) The oil has a high *thymol* content.

(3) The fruits are used in making curry powders.

(4) It has medicinal value and is useful in digestive disorders.

MEDICINAL PLANTS

ACONITE

(1) The source of the drug is the tuberous root of monk's hood (*Aconitum napellus*) of the family Ranunculaceae.

(2) The plant is a perennial herb and is an ornamental plant.

(3) The plant has medicinal value as several alkaloids are obtained from it.

(4) The most important alkaloid is *aconitine*. It is poisonous.

(5) *Aconite* is useful in *neuralgia* and *rheumatism* and in pain and fever.

RAUVOLFIA

(1) It is obtained from the roots of sarpagandha (*Rauvolfia serpentina*) of Apocynaceae family.

(2) The plant is a perennial shrub.

(3) The bark of the roots is the source of several alkaloids.

(4) The most important alkaloid is *reserpine*. It is also obtained from *R. tetraphylla* and *R. vomitoria*.

(5) *Reserpine* is used in *insanity, high blood pressure, hypertension* and *chronic psychoses*.

(6) *Serpentine, reserpinine, serpentinine, ajmaline, deserpidine, rescinnamine* are some of the important alkaloids which are obtained from the plant.

QUININE

(1) Quinine is obtained from the bark of serveral species of *Cinchona* which belongs to the family Rubiaceae.

(2) The plant is a large tree. The bark of the stem is pale, brown or dark brown in colour. The bark is taken from the stem, branches and roots. Dried bark is used for the extraction of the drug.

(3) The bark contains 4 alkaloids. These are: *quinine, quinidine, cinchonine* and *cinchonidine*. Out of these *quinine* is the most important.

(4) Quinine is white and bitter granular drug.

(5) It is used in the treatment of *malaria*. It is an *antiseptic*, and is used also as a *tonic*.

(6) *Cinchona ledgeriana, C. succirubra, C. officinalis and C. calisaya* are important species of *Cinchona*.

EPHEDRINE

(1) It is obtained from *Ephedra* of the family Gnetaceae (Gymnosperm).

(2) The plant is a leafless shrub with green stem.

(3) The drug (alkaloid) is obtained from the entire plant.

(4) The drug is useful in the treatment of *nasal* and *bronchial congestion, colds, hay fever* and even *asthama*.

(5) It is also a stimulant.

(6) The important species are *E. equisetina* and *E. sinica*.

BELLADONA

(1) It is obtained from the leaves of nightshade (*Atropa belladona*) of the family Solanaceae.

(2) The plant is a poisonous perennial herb.

(3) The drug is extracted from the dried leaves. There are several alkaloids such as *atropine, hyoscyamine, hyoscine, tropacocaine, scopolamine, apoatropine, belladonine, norhyocyamine, noratropine*, and *meteloidine*.

(4) It is used as a stimulant in *nervous trouble* as *diuretic*, in dilating the pupil of the eye and in palsy. It is also effective in relieving pain.

(5) *Atropine* is useful in eye trouble, circulation of blood, pain and muscle spasms.

(6) *Scopolamine* is effective in *insomnia, anesthesia* and is also a *narcotic.*

COCAINE

(1) It is obtained from the leaves of *Erythroxylon coca* which belongs to the family Erythroxyllaceae.

(2) The plant is a branched shrub or tree. The leaves are small, sessile and elliptical.

(3) The chief use of the drug is as a local anesthetic.

(4) It is also useful in digestive and nervous disorders.

(5) The leaves are chewed for stimulating physical and mental activities.

DIGITALIS

(1) The source of the drug is the fuxglove plant (*Digitalis purpurea*) belonging to the family Scrophulariaceae.

(2) The drug is obtained from the dried leaves.

(3) It contains glycosides such as *digitoxin, digitalin, digitalein,* and *digiton.*

(4) *Digitalis* is a stimulant for heart as it tones up circulatory system. It is also *diuretic.*

EUCALYPTUS

(1) Eucalyptus oil is obtained from the leaves of several species of *Eucalyptus* of Myrtaceae.

(2) The plant is a tall tree about 200—300 ft. in height.

(3) Eucalyptus oil is used in the treatment of *cold* and *malaria.*

(4) It is also useful in fever and in nose and throat troubles.

STRYCHNINE

(1) The drug is obtained from *Strychnos nux-vomica* which belongs to the family Loganiaceae.

(2) The alkaloids *strychnine* and *brucine* are present in the seeds.

(3) Seeds are greyish and hard.

(4) *Strychnine* is a poisonous substance. It is used in the treatment of *nervous trouble* and even *paralysis.*

(5) It is useful for central nervous system and acts as a tonic.

OPIUM

(1) It is obtained from opium poppy (*Papaver somniferum*) of Papaveraceae.

(2) *Opium* is obtained from the immature fruits.

(3) The fruits are globular in shape, pale green in colour and the type of fruit is capsule.

(4) Fine parallel slits are made into immature capsules in the evening and the latex is collected in the morning and is rolled into balls.

(5) The balls are covered by dried petals.

(6) Important alkaloids are *morphine, codeine* and *papaverine.*

Bandy
25/7/86

(7) ***Morphine*** and ***codeine*** are sedative and they relieve pain and cause sleep. Morphine is also effective in cough. They are taken orally or in injections.

(8) Opium is a ***narcotic***. It is eaten or smoked. Addiction of opium leads to ***physical and mental degradation, debility, delirium*** and even death.

ANTIBIOTICS

PENECILLIN

(1) It is an antibiotic.

(2) It is obtained from a fungus, ***Penicillium notatum***.

(3) It kills pathogenic bacteria.

(4) It is used in healing wounds, boil, and to check pus formation.

CHLOROMYCETIN

(1) It is an antibiotic.

(2) It is obtained from the bacterium ***Streptomyces venezuelae***.

(3) It kills parthogenic bacteria.

(4) It is used in the treatment of a special type of fever known as ***typhoid***.

[Note—***Streptomycin***, ***Aureomycin***, ***Terramycin*** and ***Neomycin*** are obtained from ***Streptomyces griseus***, *S. aureofaciens*, *S. rimosus* and *S. fradiae* respectively.]

SMOKING AND CHEWING MATERIALS

TOBACCO (Tambakoo or Surti)

(1) Tobacco is obtained from ***Nicotiana tabacum*** or ***N. rustica*** which belongs to the family Solanaceae.

(2) The plant has very large ovate leaves. The leaves are dried and made into tobacco.

(3) The leaves contain 70-80% water, starch, nitrogenous compounds, organic acids and 1-8% ***nicotine***, an alkaloid.

(4) Tobacco is used for smoking, chewing or snuff.

(5) It has stimulating and narcotic effect because of the presence of the alkaloid, ***nicotine***.

(6) The poor use it in '***Biris***' or in earthen pots called '***chilam***'. The rich people use it in ***cigarettes***, ***cigars*** and ***pipes*** for smoking.

BHANG

(1) It is obtained from the hemp plant (***Cannabis sativa***) of Cannabinaceae.

(2) ***Bhang*** is obtained from the tops of wild plants (mostly leaves). It is also known as ***marijuana*** (American name).

(3) It has stimulating and narcotic effect because of the presence of alkaloid.

(4) It is smoked or consumed as a beverage.

(5) It is consumed along with water (***Bhang ki thandhai***), milk or sweets.

(6) It is harmful. It causes hallucinations, erotic vision and mental unconsciousness.

GANJA

(1) It is obtained from the hemp plant (*Cannabis sativa*) of Cannabinaceae.

(2) It is made from dried and powdered young female inflorescences and very young leaves.

(5) It is stimulating and is a narcotic because of the presence of the alkaloid.

(4) It is smoked and its effect is harmful. It causes hallucinations, erotic visions. mental unconsciousness etc.

CHARAS OR HASHISH

(1) It is obtained from the hemp plant (*Cannabis sativa*) of Cannabinaceae.

(2) It is extracted from the young female inflorescence.

(3) The resinous secretion from the female inflorescences are collected (before the flowers are fertilized) and made into a pure resin called '*charas*' or '*hashish*'.

(4) It is a stimulant and a narcotic.

(5) It is very dangerous to smoke it. It takes away the mental consciousness and lands the man into a world of unreality. The modern society, especially the west, is full of such addicts called '*hippies*'.

OPIUM

(1) It is obtained from the opium poppy (*Papaver somniferum*) which belongs to the family Papaveraceae.

(2) *Opium* is the dried juice (*latex*) which exudes from the unripe fruits after making slight incisions.

(3) It contains alkaloids such as *morphine, codeine, narcotine* and *papaverine.*

(4) It is eaten or smoked. It has stimulating and narcotic effect.

(5) *Morphine* and *codeine* are used in medicines for the relief of pain.

(6) The seeds contains 44-50% *drying oil* which is used in sweetmeats, curry, and in the manufacture of paints and soaps.

COCA

(1) It is obtained from coca plant (*Erythroxylon coca*) of the family Erythroxyllaceae.

(2) The leaves contain the drug *cocain.*

(3) The leaves mixed with lime and alkaline ashes of some plant are chewed.

(4) It stimulates physical and mental activities and kills hunger and pain.

(5) Excessive chewing is dangerous for health because it results in physical disability and disease.

COLA or KOLA

(1) It is obtained from cola plant (*Cola nitida*) of the family Sterculiaceae.

(2) The plant is a tree and the cola nuts are the seeds which is used as chewing material.

(3) It has stimulating effect and is helpful in fatigue and hunger.

(4) The nut contains 2% *caffein*, an *essential oil*, and a glucoside *kolanin*.

(5) *Caffein and Kolanin* are responsible for the stimulating effect of the nuts or seeds.

[Note : Both *Coca* and *Cola* are used in the preparation of a soft drink called '*Cocacola*'.]

PAAN or BETEL

(1) It is a very popular chewing material.

(2) Betel has four or five principal ingredients :

(i) Leaf of betel (*Piper betle*) of the family Piperaceae.

(ii) Seed or nut of Areca palm, *supari* (*Areca catechu*) of Palmaceae.

(iii) A *resin* called '*kattha*' obtained from *Acacia catechu* of Leguminosae.

and (iv) lime.

(3) Betel is chewed after pasting *kaltha* and lime on the betel leaves along with a few pieces of *supari*.

(4) Tobacco (*Nicotiana tabacum* or *N.rustica* leaves of Solanaceae is also taken along with the 'pan' by those who take tobacco.

(5) Those who do not like tobacco, take cloves or *laung*. (*Syzygium aromaticum syn. Engenia caryophyllata*) of Myrtaceae and *illaychi* (*Elettaria sp.*) of Zingiberaceae for flavour.

(6) It helps in the secretion of saliva which is helpful in the digestion of food.

(7) Pan is also offered to guests.

(8) Betel leaves and supari is used in religious functions and ceremonies and are offered to Gods and Goddesses.

MISCELLANEOUS

ROOTS OF KHAS-KHAS (Vetiver)

(1) These are the roots of *Khas-Khas* (*Vetiveria zizanoides*) which belongs to the family Graminaceae (Poaceae).

(2) The roots yield an oil known as *Khas-khas oil*. It is used in making soap and perfume.

(3) Roots are used in making curtains for doors and windows. When moist these cool the rooms during summer.

'BIRIS'

(1) These are '*Biris*'.

(2) Biris are made of three components.

(i) Tobacco (*Nicotiana tobacum* or *N. rustica*) of Solanaceae. It is smoked & is narcotic.

(ii) The leaves of *tendu*, *Diospyros melanoxylon* of Ebenaceae, serve as plates and are largely used as wrappers for '*Biris*'.

(iii) Thread (*Gossypium Sp.*) of Malvaceae family, serves to tie the *Birls.*

(3) Tobacco is smoked. It is a stimulant and a narcotic. It is very popular among the poor people.

(4) Excessive smoking is harmful.

INDIGO

(1) It is obtained from *Indigo plant, Indigofera tinctoria* and I. *suffruticosa* of Leguminosae family.

(2) The leaves yield a dye called *Indigo.*

(3) It is used in textile industry for giving colour to fabrics.

(4) It is also used in colouring paints, varnishes, leather, ink, paper etc.

CANADA BALSAM

(1) It is obtained from a gymnosperm *Abies balsamea* (Pinaceae).

(2) It contains less oil than turpentine and is thick viscous liquid.

(3) It has characteristic smell and odour due to presence of benzoic acid.

(4) It is widely used in histological works as a mounting medium, in perfume industry as fixative, as adhesives and flovourings.

RATTY

(1) These are the seeds of ratty (*Abrus precatorius*) of Papilionaceae (Fabaceae).

(2) Powdered seeds are used to increase adhesion in souldering oranaments.

(3) Seeds contain the posion '*abrin*' and is used in poisoning cattles.

(4) Seeds used by jwellers as a unit of weight called 'ratty.' Each seed is about 1.75 grams (*One ratty*).

CANE OR BENT (Calamus)

(1) It is the stem of *ratan cane* (*Calamus rotang*) of the family Palmaceae.

(2) Nodes and internodes well marked and the stem is slender and climbing.

(3) Cane is made into baskets, furniture, wicker-work, umbrella ribs ropes, cables etc.

(4) Ropes made out of the cane are used in dragging heavy weights and for tethering wild elephants.

(5) It is also used for building suspension bridges over rivers and streams, as substitute for whole bone, and for stiffening bonnets.

(6) Tender shoots and seeds are edible.

BHOJPATRA

(1) The bark is obtained from Indian Paper Birch or White Himalayau Birch (*Betula utilis*) which belongs to the family Betulaceae.

(2) The bark is smooth, marked with white, horizontal spots, outer bark white consisting of papery pink layers. It exfoliates in broad horizontal rolls.

(3) The outer bark is used for writing purposes.

(4) It is used for umbrella covers, lining roof from inside to make them water tight, packing fruits and covering hooka-tubes.

(5) The bark posses aromatic and antiseptic properties.

(6) The wood is used for building purposes.

MUNJ OR SARKANDA

(1) It is a very tall (stem upto 18ft. high), erect grass growing in clumps.

(2) The fibre commonly known as *'munj'* is obtained from the leaves and stems of *Saccharum munja* of Graminaceae.

(3) Fibres are made into ropes which are used for making baskets mats, in rigging boats, for tying up cattles etc.

(4) Leaves are used for making paper and for thathing houses.

(5) Stems are also used for thathing house boats and carts etc.

INDIAN WILLOW TREE

(1) Bat and cricket equipments are made from the wood of Indian Willow Tree (*Salix tetrasperma*) which belongs to the family Salicaceae.

(2) The wood is light red or reddish-brown, soft and porous.

(3) In Madras the wood is used for making *pencils*.

(4) It is suitable for match industry.

(5) The bark is used for tanning material.

(6) Young shoots and branches are woven into baskets and wicke work.

CHANDAN

(1) It is obtained from chandan, *Sandal wood tree* (*Santalum album*) of Santalaceae.

(2) The wood is yellowish-brown to dark brown, hard and highly scented.

(3) The most valuable part of the wood is its inner part, the, heart wood.

(4) Oil extracted from the heart wood is used in perfumery, soaps, in scenting inferior woods etc.

(5) Oil is also used as an insecticide and as insect repellent. It has medicinal uses.

(6) Heart wood saw-dust is made into scented cakes and sticks to be burnt as incence.

(7) Paste of the wood made with water is used for making caste marks by Hindus.

FRUIT OF AMLA (Emblic Myrobalan)

(1) The fruit is the most important part of the plant (*Emblica officinalis*) which belongs to the family Euphorbiaceae.

(2) The fruit is edible and can be made into *'chutnis'*, *'achar'* (pickle) and *'murabba'*.

(3) The fruit yields tanning and dyeing material due to presence of *tanin*. The dye is used for dyeing silk and it is not suitable for cotton.

(4) Dried fruit is used as shampoo for the head, and is an ingredient for making ink and hair dyes.

(5) It has a number of medicinal uses. It is used in digestive disorders, as hair and brain tonic, in cough and could and in a number of heart and liver diseases. It is also a diuretic.

FRUIT OF HARRA (Chebulic Myrobalan)

(1) The fruit is the most valuable part of the plant (*Terminala chebula*) of the family Combrataceae.

(2) The fruits yield a *tanning* material for dyeing cotton, wool, and leather.

(3) It is also useful in the preparation of inks and *tanic acid* in other countries.

(4) The fruit is also used in making sweet conserves and the dried and powdered fruit pulp.is used as a dentrifice.

(5) The fruit has a number of medicinal uses. It is useful in improving digestive disorders, cough and cold, liver disorders, useful for eyes and a number of heart and nervous troubles.

FRUIT OF BAHERA (Beleric Myrobalan)

(1) The fruit is the most useful part of the plant (*Terminalia bellirica*) belonging to the family Combrataceae.

(2) The fruit yields tanning and dyeing materials for tanning leather and dyeing cloth and leather due to the presence of tanin in the fruits.

(3) Fresh fruit is used for making inks.

(4) The fruit is an astringent and has medicinal properties.

(5) It is used in respiratory troubles, in cough and cold, improving digestion, skin diseases, and is also useful for eyes and hairs.

TRIHPALA

The famous Ayurvedic medicine is made from the dried fruits of *amla*, *harra* and *bahera*.

ISOBGOL

(1) It is obtained from *Plantago ovata* of the family Plantaginaceae.

(2) The seeds contain a tasteless mucilagionus substance which when wetted, swells up.

(3) It is mild laxative and is used in chronic constipation.

(4) The mucilage can also be used as a cosmetic and in stiffening fabrics.

(5) It is sold in the markets in packets under the name *'Isobgol Ki Bhusi'*.

LAHSUN (Garlic)

(1) It is a bulb of garlic (*Allium sativum*) of Liliaceae family.

(2) The stem is reduced and disc shaped. Roots are fibrous and the leaves are flat and acicular.

(3) The basal part of the leaf is swollen due to accumulation of food material.

(4) It has a pungent smell.

(5) It is used in the preparation of vegetables and in a number of preserves.

(6) Its effect is antiflattulent and it improves digestion and removes constipation. It helps to clear coughs.

(7) It is antibacterial and is effective in blood pressure and heart trouble by reducing the deposition of *cholestrol* in the *aorta.*

(8) Now it is available in the form of pearls (capsules) under the name *'LASONA'*

HEENG (Asafoetida)

(1) It is obtained from *Ferula foetida* belonging to the family Umbelliferae (Apiaceae).

(2) It is a gummy exudation from the underground parts of the stem.
(3) It is used as spices in cooking vegetables.
(4) It has a number of medicinal uses.
(5) It is carminative, digestive, diuretic, sedative and is effective in dyspepsia, hysteria, cholera and in colic pain.

LICHEN (Chabila)

(1) A number of lichens (*Parmelia sp, Usnea sp.*, *Ramalnia* sp. etc.) as used in spices.

(2) Lichens are composite structures of an alga (*Cyanophyceae*) and a fungus (*Ascomycetes* or *Basidiomycetes*).

(3) The dried thalli are used in cooking vegetables and meat, for flavonring.

(4) Lichens also yield dyeing meterials.

(5) They are also used in medicines.

RITHA

(1) It is obtained from the plant *Sapindus laurifolius* which belongs to the family Sapindaceae.

(2) The dried fruit has several uses.

(3) The extract of the fruit is used in washing cotton and wollen cloth and also silver ornaments and utensils.

(4) It has also medicinal uses. A paste is made with vinegar and is effective when applied on the wounds due to snake bites and some other reptiles and is used by the villagers.

SAGO (Sabudana)

(1) It is obtained from the sago plant (*Metroxylon rumphii*) of the family Palmaceae.
(2) It is extracted from the pithcells.
(3) It contains carbohydrate.
(4) It is a light food and is boiled with water or milk.
(5) It is given to children, old and weak persons after illness.

CHILGOZA

(1) These are the seeds of chilgoza (*Pinus gerardiana*) of Pinaceae.
(2) The seeds are edible.
(3) The seeds have thin covering or shell. The shell is removed by roasting the cone.
(4) This is a brain tonic.
(5) It is also used in making sweets and in a number of food porducts.

CHAPTER 6

Taxonomy

DESCRIPTION OF PLANTS

RANUNCULACEAE

Example 1. *Ranunculus sceleratus* (Buttercup)

Habit—Herb (annual).

Root—Tap root, branched.

Stem—Aerial, erect, branched, green, angular, herbaceous, smooth, fistular, nodes and internodes well marked.

Leaf—Ramal and cauline, simple, alternate, petiolate, exstipulate, leaf base membranous and escheaving, lamina much dissected, lobes ovate, entire, obtuse, glabrous, mutticostate reticulate, leaves present on the apical portion of the stem comparatively less dissected.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate (1 bract and 2 bracteoles), complete, actinomorphic regular, bisexual (hermaphrodite), pentamerous, hypogynous, yellow.

Calyx—Sepals 5, polysepalous, imbricate, odd sepal posterior, sepals boat-shaped and slightly petaloid.

Corolla—Petals 5, polypetalous, imbricate, odd petal anterior, alternate (with sepals), pocket-shaped nectary at the base of each petal, yellow.

Androecium—Stamens numerous (indefinite), polyandrous, spirally arranged, filament long, anther bithecous (dithecous), basifixed, extrorse.

Gynoecium—Polycarpellary, apocarpous, unilocular, one ovule in each locule, placentation basal, sytle highly reduced, stigma beaked, simple and sticky, ovary superior, spirally arranged.

Fruit—Etario of achenes.

Floral Formula

$$Br,\quad \oplus,\quad \varsigma^{\mathfrak{o}}_{\mathfrak{q}}\quad K_5,\quad C_5,\quad A\infty,\quad \underline{G\infty}.$$

Classification and identification

Class—Dicotyledons
Sub-class—Polypetalae
Series—Thalamiflorae
Order—Ranales
Family—Ranunculaceae
Genus—*Ranunculus* (Butter cups or cowfoot)

DICOTYLEDONS

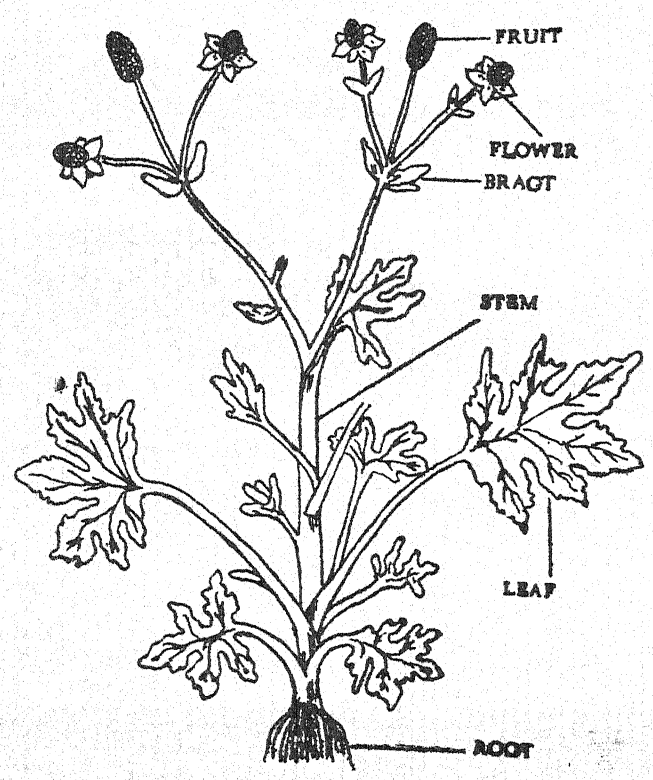
1. Leaf vennation reticulate.
2. Embryo dicotyledonous.
3. Flower pentamerous.

POLYPETALAE

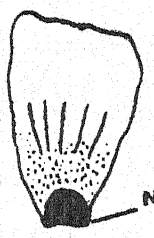
1. Petals free.
2. Sepals and petals both present.

THALAMIFLORAE

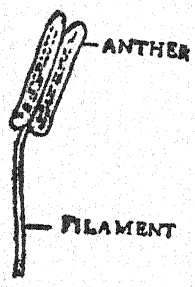
1. Flowers bisexual and regular.
2. Ovary hypogynous and superior.
3. Torus or thalamus dome-shaped (not expanded into a disc).



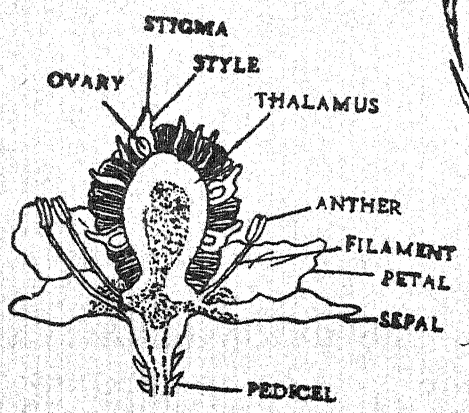
A PLANT



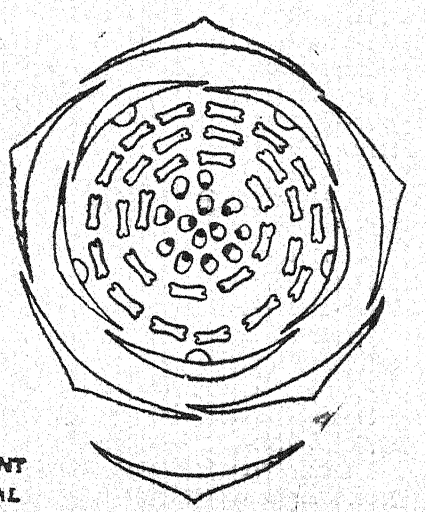
PETAL



STAMEN



L. S. FLOWER



FLORAL DIAGRAM

Fig. 182. *Ranunculus sceleratus* (*Ranunculaceae*)

RANALES

1. Stamens indefinite.
2. Carpels free (apocarpous) or immersed in torus.

RANUNCULACEAE

1. Herbs with dissected leaves.
2. Stamens indefinite, spiral, extrorse.
3. Carpels free.

Example 2. *Clematis paniculata* (Traveller's joy).

Habit—A climbing shrub.

Root—Tap root.

Stem—Climbing, herbaceous, branched, aerial, angular, solid, smooth, glabrous and green.

Leaf—Cauline (also ramal), compound, opposite decussate, exstipulate, petiolate, petiole long, coiling (tendril), leaflets three, each leaflet ovate, entire, acute, unicostate reticulate vennation (leaf multicostate).

Inflorescence—Solitary, axillary.

Flower—Pedicellate, bracteate (1) bract and 2 bracteoles), incomplete, actinomorphic, bisexual, tetramerous, hypogynous, white.

Calyx—Sepals absent.

Corolla—Petals 4, polypetalous, valvate aestivation, white, scented.

Androecium—Stamens indefinite, polyandrous, arranged in several rows, alternating with each other, filaments of outer stamens longer, filaments hairy, anthers bithecous, basifixed, extrorse.

Gynoecium—Polycarpellary, carpels 4-6, apocarpous, ovary unilocular, basal placentation, superior, style 1, hairy, persistent, stigma simple.

Fruit—Etario of single seeded achenes.

Floral Formula

$$Br,\ \oplus,\ \varphi^{\mathfrak{Z}},\ K_0,\ C_4,\ A\infty,\ \underline{G\infty},$$

Systematic Position

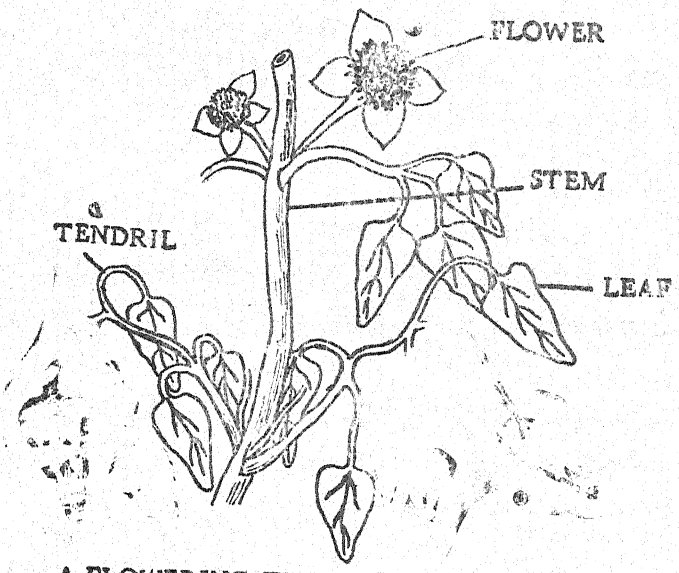
Class—Dicotyledons

Sub-class—Polypetalae

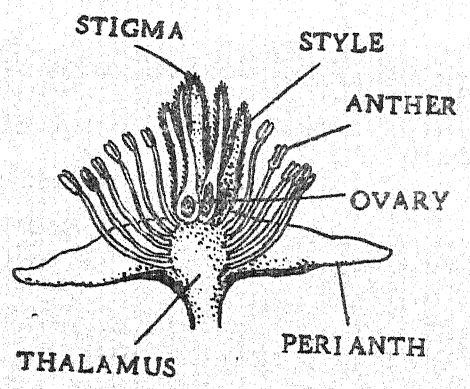
Series—Thalamiflorae

Order—Ranales

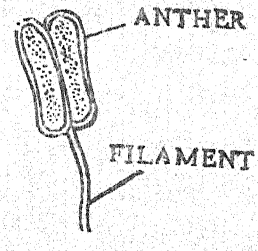
Family—Ranunculaceae



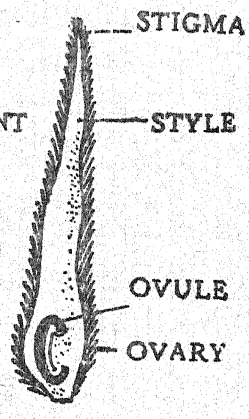
A FLOWERING TWIG



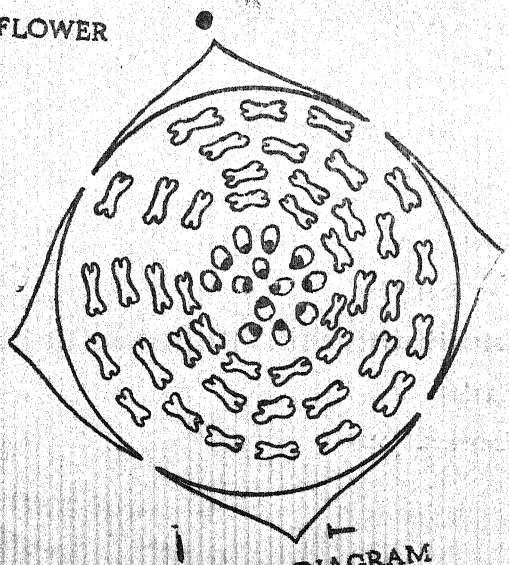
L. S. FLOWER



STAMEN



L. S. PISTIL



FLORAL DIAGRAM

Fig. 183. ***Clematis paniculata*** **(Ranunculaceae)**

Example 3. *Nigella sativa* (Hindi-Kalajeera)

Habit—A cultivated annual herb.

Root—Tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, glabrous and green.

Leaf—Cauline, sessile, alternate, exstipulate, sheathing at base, simple, much dissected, glabrous, multicostate reticulate vennation.

Inflorescence—Solitary terminal.

Flower—Pedicellate, ebracteate, incomplete, bisexual, actinomorphic, hypogynous, greenish-white.

Calyx—Sepals 5, polysepalous, imbricate, odd sepal posterior.

Corolla—Petals 8, polypetalous, transformed into bifid nectaries, greenish-white, valvate.

Androecium—Stamens indefinite, polyandrous, spiral, in 8 rows of 5 each, filaments long, anther bithecous, basifixed, extrorse.

Gynoecium—Polycarpellary, carpels usually 5, partially fused, fused below but free above, pentalocular ovary, 2 ovules in each locule, placentation axile, ovary superior, styles 5, hairy, stigma 5, simple.

Fruit—Capsule.

Floral Formula

$\oplus$, φ^{σ}, K_5, C_8 (nectaries), $A\infty$, $\underline{G(5)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Ranales

Family—Ranunculaceae

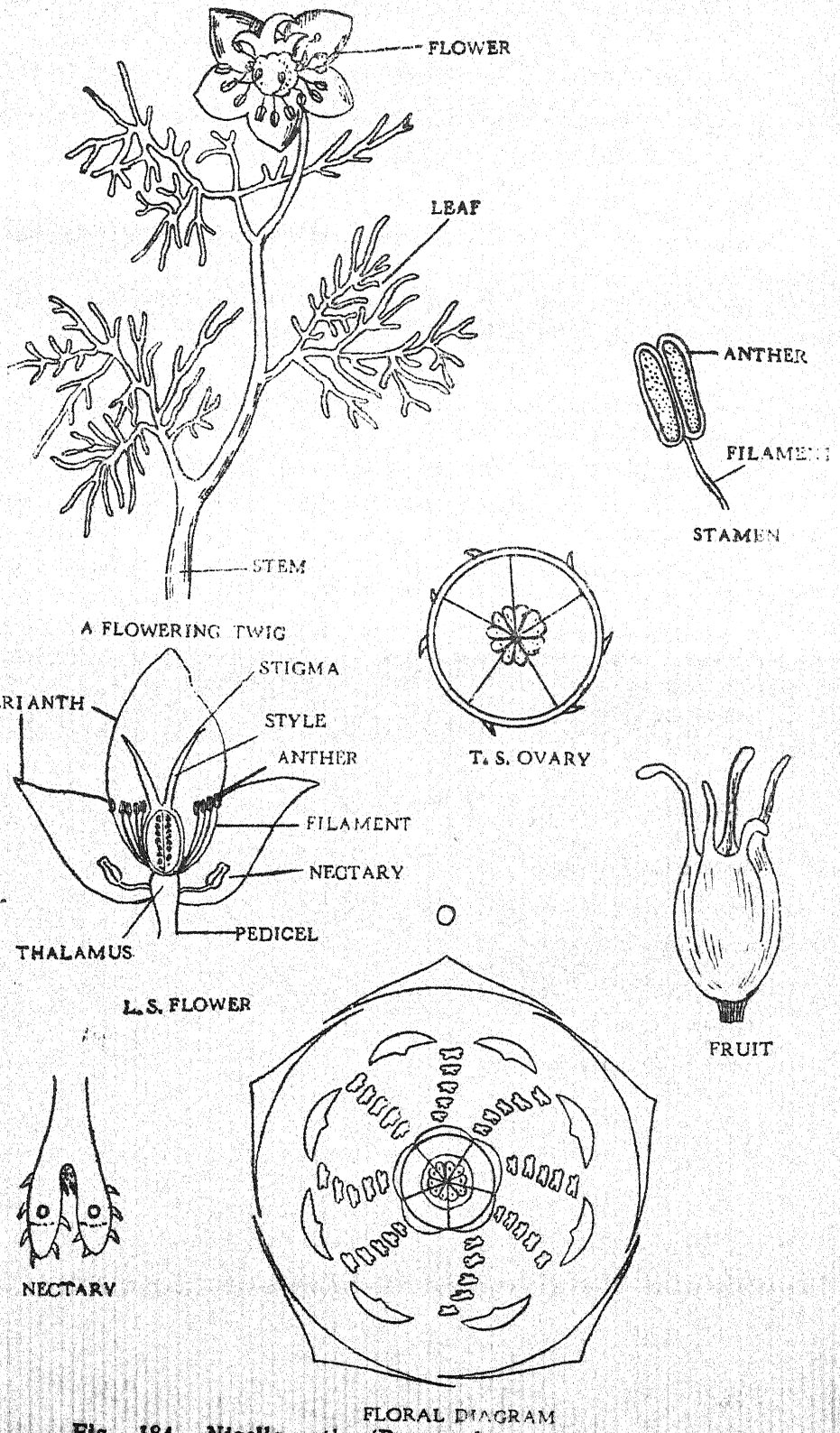


Fig. 184. ***Nigella sativa*** **(Ranunculaceae)**

Example 4. *Delphinium ajacis* (Larkspur)

Habit—A cultivated annual herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, herbaceous, glabrous, fistular and green.

Leaf—Cauline, simple, sessile, alternate, exstipulate, much dissected, segments linear-lanceolate, entire, acute, multicostate reticulate.

Inflorescence—Racemose, terminal or axillary.

Flower—Pedicellate, bracteate, complete, bisexual, zygomorphic, hypogynous, spurred posteriorly, violet coloured (in different varieties, colour is different).

Calyx—Sepals 5, polysepalous, petaloid, imbricate, posterior sepal spurred and carries the nectary.

Corolla—Petals 4, gamopetalous, imbricate, 2 posterior petals form spur which fits into the posterior spurred sepal, anterior petal absent.

Androecium—Stamens 15 spirally arranged, in 5 five groups, each group has 3 stamens, polyandrous, alternate with petals, anthers dithecous, filaments flattened, tapering, basifixed, extrorse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, many ovules, superior ovary, style reduced and stigma simple.

Fruit—Follicle.

Floral Formula

$$Br,\ \%,\ \mathcal{Q}^{\mathcal{J}}_{+}\ K_5,\ C_{(4)},\ A_{15},\ \underline{G_1}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Ranales

Family—Ranunculaceae

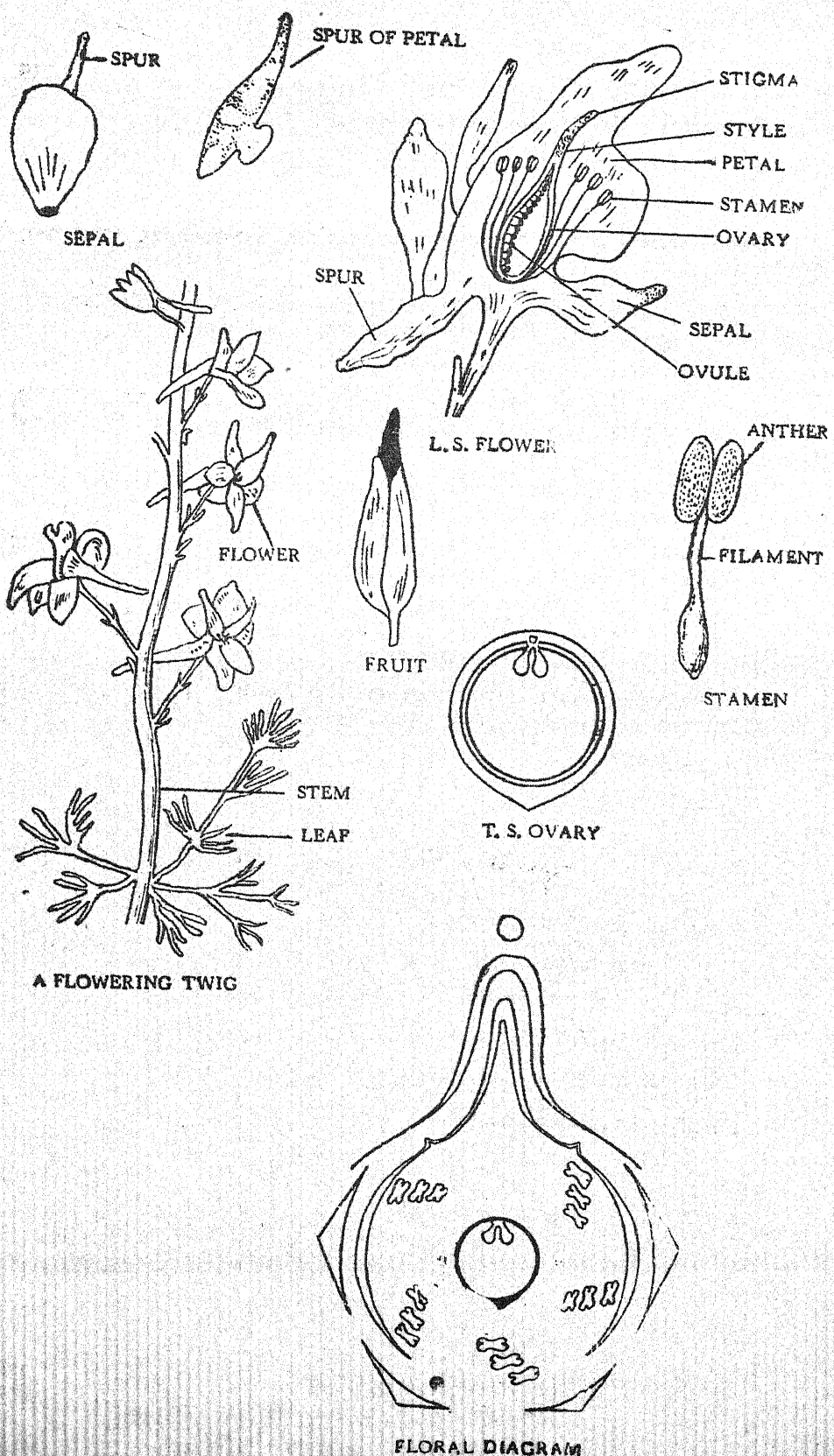


Fig. 185. *Delphinium ajacis* (Ranunculaceae).

CRUCIFERAE (BRASSICACEAE)

Example 1. *Brassica campestris* (Mustard or sarson)

Habit—A biennial cultivated herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, solid, herbaceous, green hairy,

Leaf—Cauline, simple, sessile, exstipulate, alternate, lower leaves deeply dissected, lyrate, serrate, acute unicostate reticulate, hairy.

Inflorescence—Racemose raceme.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, tetramerous, cyclic, hypogynous, yellow.

Calyx—Sepal 4, in 2 whorls, polysepalous, slightly petaloid.

Corolla—Petals 4, polypetalous, cruciform, valvate, petal with claw and limb.

Androecium—Stamens 6, polyandrous, tetradynamous (4 inner long and 2 outer short), dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular but becomes bilocular due to replum (false septum), ovules many in each locule, placentation parietal, ovary superior, style short, stigma bilobed.

Fruit—Siliqua

Floral Formula

$\oplus$, φ^{σ}, $K_{2}+_{2}$, C_{4}, $A_{2}+_{4}$, $G\ \underline{(2)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

[Carpels united, unilocular, parietal placentation]

Family—Cruciferae (Brassicaceae)

[Corolla cruciform, stamens tetradynamous, ovary bicarpellary, syncarpous, unilocular but becomes bilocular due to replum].

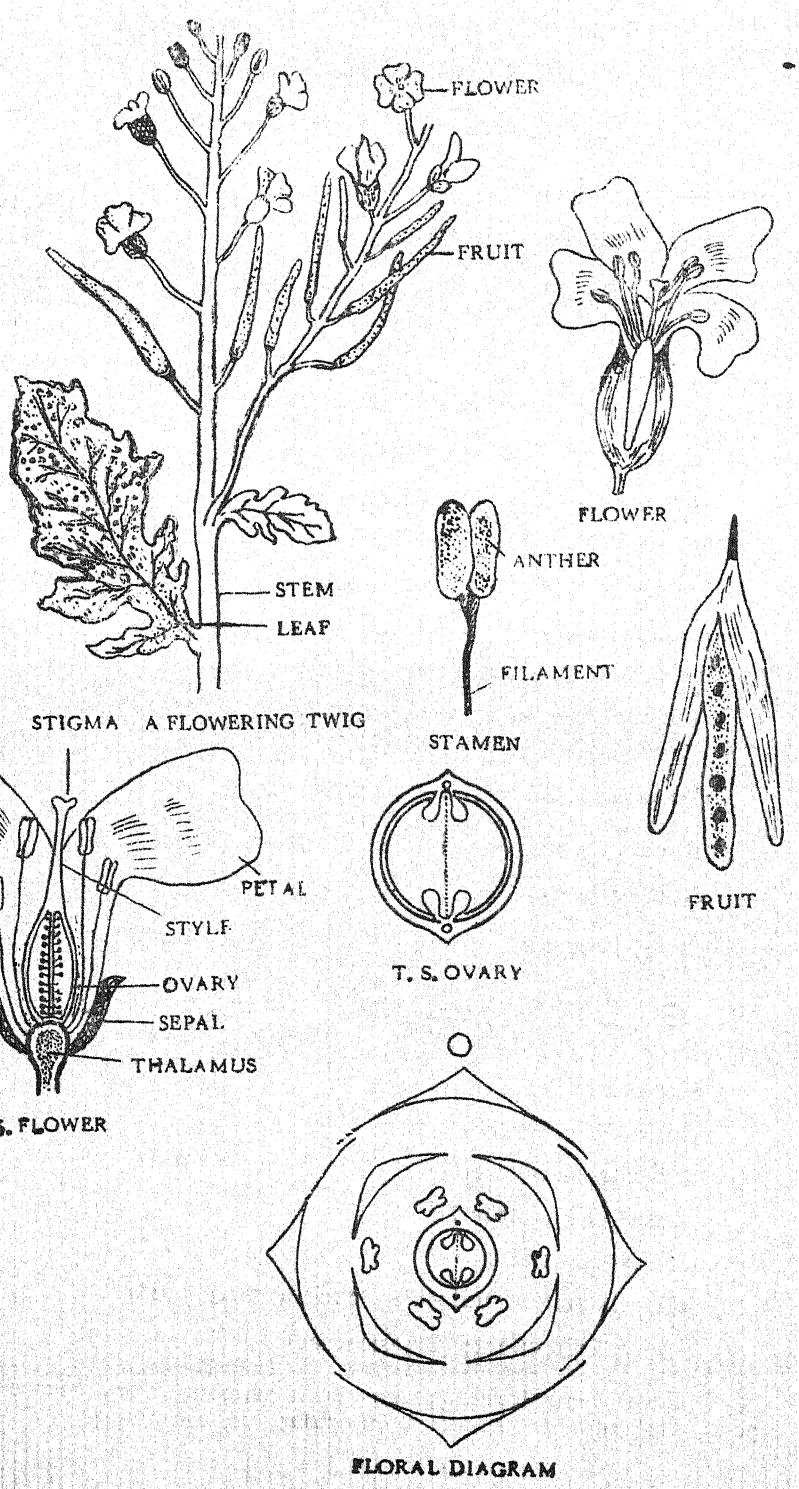


Fig. 186. ***Brassica campestris*** **(Cruciferae)**

Example 2.—*Raphanus sativus* (Radish, Hindi-Muli)

Habit—A cultivated biennial herb.

Root—Tap root, conical, fleshy, edible.

Stem—Aerial, erect, branched, cylindrical, herbaceous, green, glabrous.

Leaf—Radical, sessile, simple, alternate, pinnatifid, exstipulate, apex lobed, unicostate reticulate, hairy.

Inflorescence—Racemose.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, white.

Calyx—Sepals 4, in 2 whorls of 2 each, polysepalous, valvate.

Corolla—Petals 4, polypetalous, cruciform, imbricate (in bud).

Androecium—Staments 6, polyandrous, tetradynamous, filament long, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, parietal placentation, superior ovary, style short, stigma bilobed.

Fruit—Indehiscent beaked siliqua.

Floral Formula

$\oplus$, φ, $K_{2}+_{2}$, C_{4}, $A_{2}+_{4}$, $G\underline{(2)}$.

Systematic Position

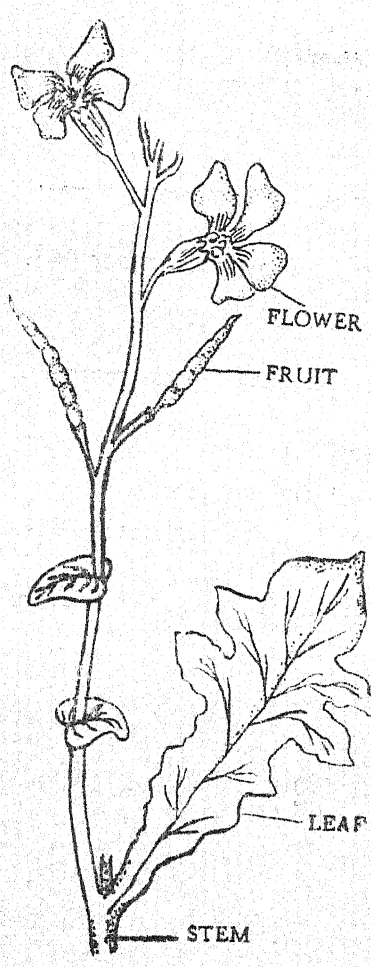
Class—Dicotyledons

Sub-class—Polypetalae

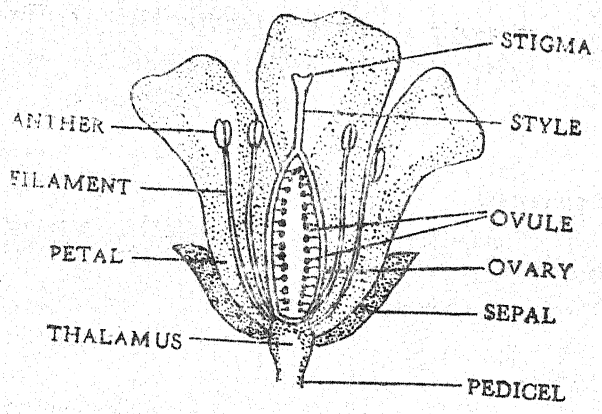
Series—Thalamiflorae

Order—Parietales

Family—Cruciferae (Brassicaceae)



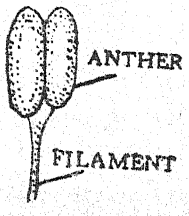
FLOWERING TWIG



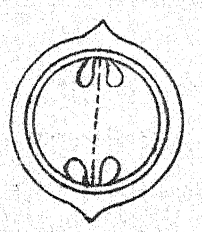
L. S. FLOWER



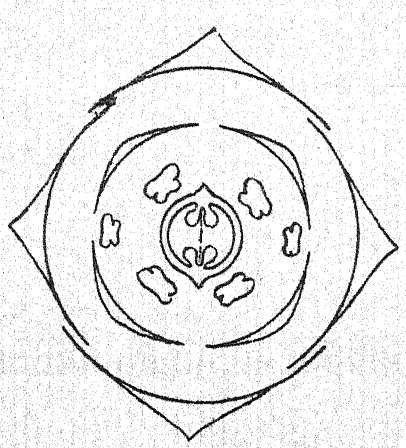
PETAL



STAMEN



T. S. OVARY



FLORAL DIAGRAM

Fig. 187. ***Raphanus sativus*** **(Cruciferae).**

Example 3. *Cherianthus cheiri* (Wall flower)

Habit—An annual cultivated herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, solid, herbaceous.

Leaf—Cauline, simple, sessile, exstipulate, linear-lanceolate, entire, acute, unicostate reticulate.

Inflorescence—Corymbose raceme.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic hypogynous, yellow.

Calyx—Sepals 4, polysepalous, in two whorls of 2 each, odd sepal posterior, imbricate.

Corolla—Petals 4, polypetalous, cruciform, valvate, yellow.

Androecium—Stamens 6, polyandrous, tetradynamous, filament long, anther dithecous, basifixed, extrorse, nectaries may be present at the base of the stamens.

Gynoecium—Bicarpellary, syncarpous, unilocular or bilocular due to false septum, parietal placentation, superior ovary, style short, stigma bifid.

Fruit—Siliqua

Floral Formula

$\oplus$, φ^{σ}, $K_{2}+_{2}$, C_{4}, $A_{2}+_{4}$, $\underline{G\ (2)}$

Systematic Position

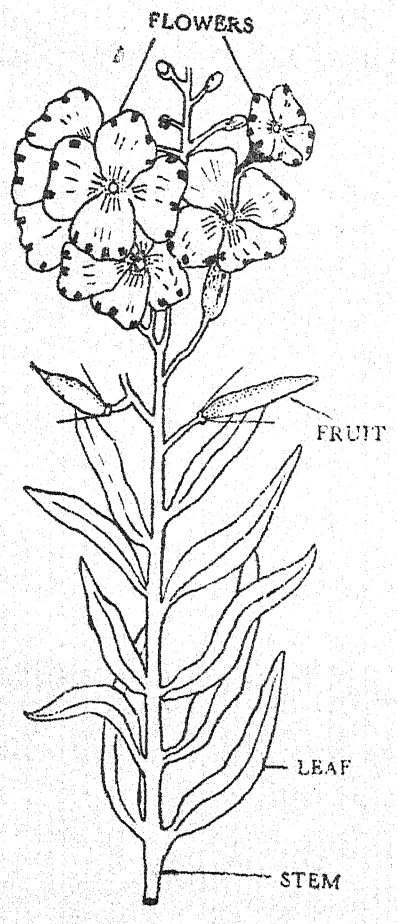
Class—Dicotyledons

Sub-class—Polypetalae

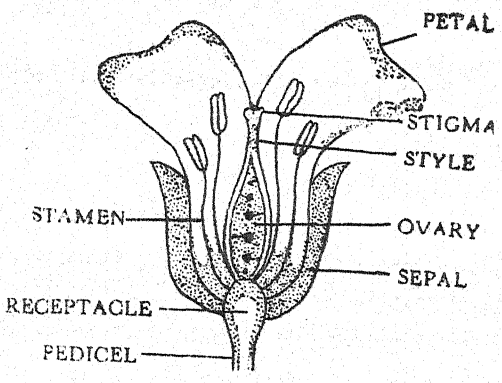
Series—Thalamiflorae

Order—Parietales

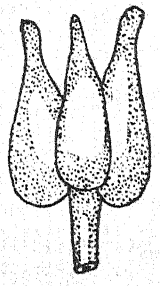
Family—Cruciferae



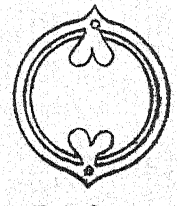
A FLOWERING TWIG



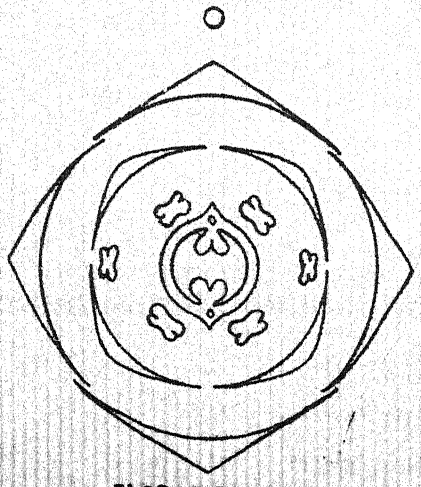
L. S. FLOWER



CALYX



T. S. OVARY



FLORAL DIAGRAM

Fig. 188. ***Cheiranthus cheiri*** **(Cruciferae)**

Example 4. *Senebiera didyma* Syn. *Coronopus didymus* (Lesser wart-cress).

Habit—An annual herb.

Root—Tap root, branched.

Stem—Aerial, prostrate, branched, herbaceous, solid, green, glabrous.

Leaf—Cauline, simple, sessile, alternate, exstipulate, pinnatifid, (deeply dissected), glabrous, multicostate reticulate.

Inflorescence—Racemose.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, small, greenish-white, hypogynous.

Calyx—Sepals 4, polysepalous, in 2 whorls of 2 each, imbricate, odd sepal posterior.

Corolla—Petals 4, polypetalous, minute, valvate, greenish-white or white, petals pointed.

Androecium—Stamens only 2, polyandrous, placed anterio-posteriorly, filament short, anther dithecous, dorsifixed, extrorse.

Gynoecium—Bicarpellary, syncarpous bilocular, parietal placentation, superior ovary, style highly reduced, stigma disc like.

Fruit—Silicula.

Floral Formula

$\oplus$, φ $K_{2}+_{2}$, C_{4}, A_{2}, $G\ \underline{(2)}$.

Systematic Position

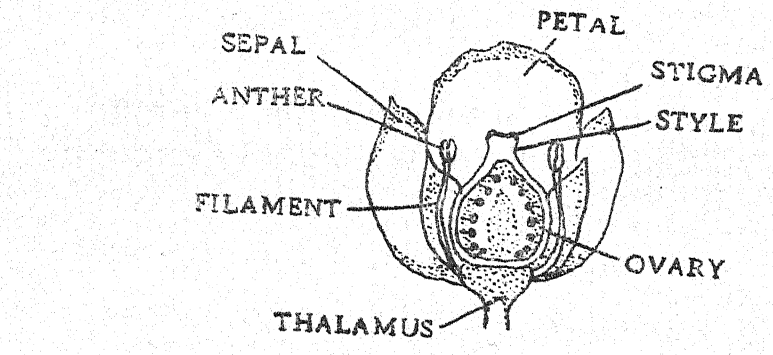
Class—Dicotyledons

Sub-class—Polypetalae

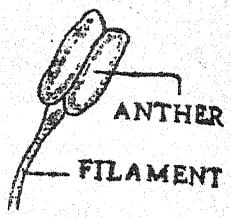
Series—Thalamiflorae

Order—Parietales.

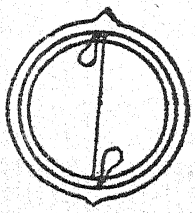
Family—Cruciferae



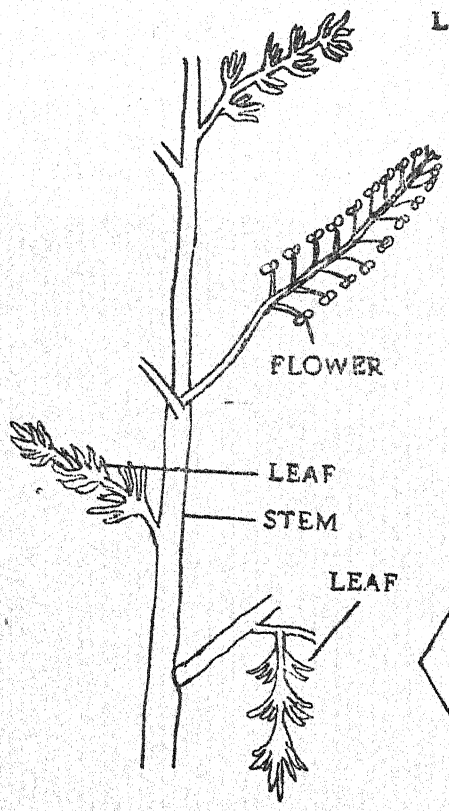
L. S. FLOWER



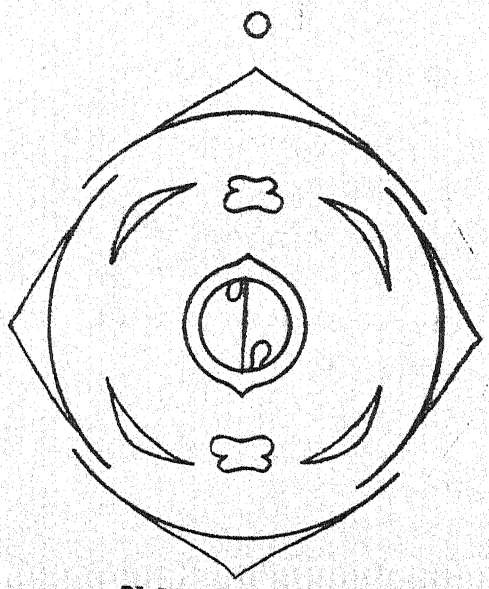
STAMEN



T. S. OVARY



A FLOWERING TWIG



FLORAL DIAGRAM

Fig. 189. ***Coronopus didymus*** **Syn.** ***Seneblera didyma*** ***(Cruciferae)***

Example 5. *Iberis amara* Syn. *I. coronaria* (Rocket Candytuft : Hindi-Chandni).

Habit—A cultivated annual herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, solid, herbaceous, glabrous, green.

Leaf—Cauline, simple, sessile, exstipulate, alternate, lanceolate, serrate, acute, glabrous, unicostate reticulate.

Inflorescence—Corymb.

Flowers—Pedicellate, ebracteate, complete, bisexual, actinomorphic, zygomorphic, tetramerous, hypogynous, white. Flowers in the central region are actinomorphic and peripheral flowers are zygomorphic.

Calyx—Sepals 4, polysepalous, in two whorls of 2 sepals each, imbricate, odd sepal posterior.

Corolla—Petals 4, polypetalous, cruciform (2 petals small and 2 large), in actinomorphic flowers all the petals are of equal size, valvate (rarely imbricate).

Androecium—Stamens 6, polyandrous. tetradynamous, filament short, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, parietal placentation, superior ovary, style short, stigma bifid.

Fruit—Silicula.

Floral Formula

% or ⊕, ♂♀, $K_{2}+_{2}$, C_{4}, $A_{2}+_{4}$, $\underline{G(2)}$.

Systematic Position

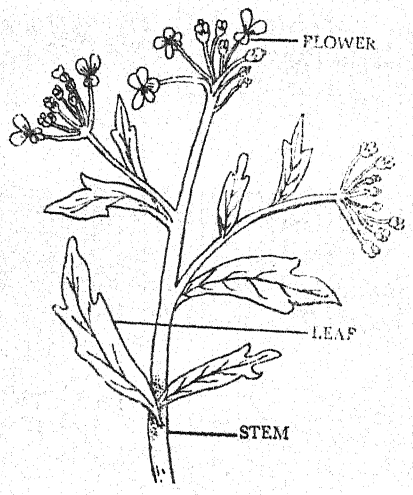
Class—Dicotyledons

Sub-class—Polypetalae

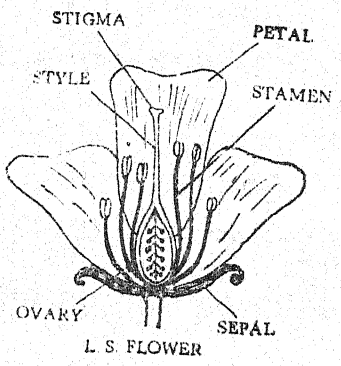
Series—Thalamiflorae

Order—Parietales

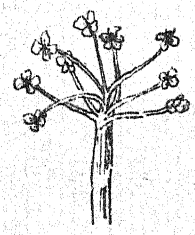
Family—Cruciferae



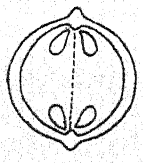
A FLOWERING TWIG
ZYGOMORPHIC FLOWER



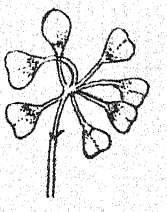
L. S. FLOWER



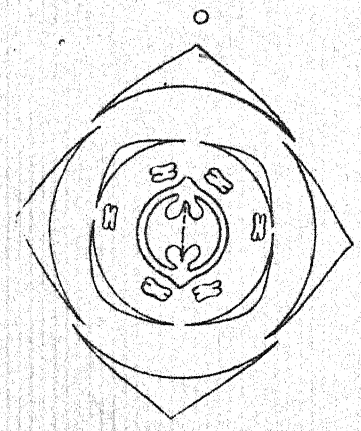
A FLOWERING TWIG
ACTINOMORPHIC FLOWER



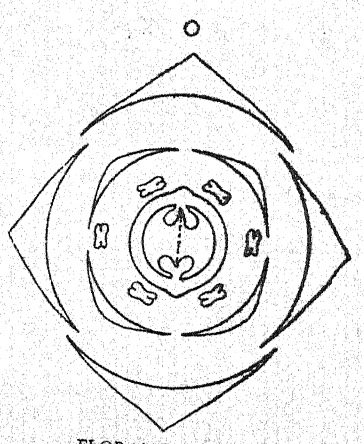
T. S. OVARY



FRUIT



FLORAL DIAGRAM
ZYGOMORPHIC FLOWER



FLORAL DIAGRAM
ACTINOMORPHIC FLOWER

Fig. 190. ***Iberis amara*** **(Cruciferae).**

CAPPARIDACEAE

Example 1. *Cleome viscosa* (Hindi-Pili hulhul)

Syn. **Cleome gynandra** (*Gynandropsis pentaphylla*)

Habit—Wild annual herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, herbaceous, cylindrical or angular, solid, pubescent, green.

Leaf—Cauline, palmately compound, alternate, petiolate, exstipulate, 3 foliate or 5 foliate, leaflets ovate to lanceolate, sessile, entire, acute, hairy, each leaflet unicostate reticulate, leaf is multicostate reticulate.

Inflorecence—Racemose raceme.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, tetramerous, hypogynous, cyclic, yellow.

Calyx—Sepals 4, in 2 whorls of 2 each, polysepalous, imbricate.

Corolla—Petals 4, polypetalous, valvate (imbricate in bud), clawed, yellow.

Androecium—Stamens indefinite, polyandrous, filaments long and slender, anther dithecous, basifixed, anther curved, introrse, androphore highly reduced or absent.

Gynoecium—Bicarpellary, syncarpous, unilocular, parietal placentation, many ovules, superior ovary, style short, stigma capitate and sticky, gynophore short.

Fruit—Capsule.

Floral Formula

$\oplus$, $\varsigma^{\prime}_{\varsigma}$, $K_{2}+_{2}$, C_{4}, $A\infty$, $\underline{G(2)}$.

Systematic Position

Class—Dicotyledons

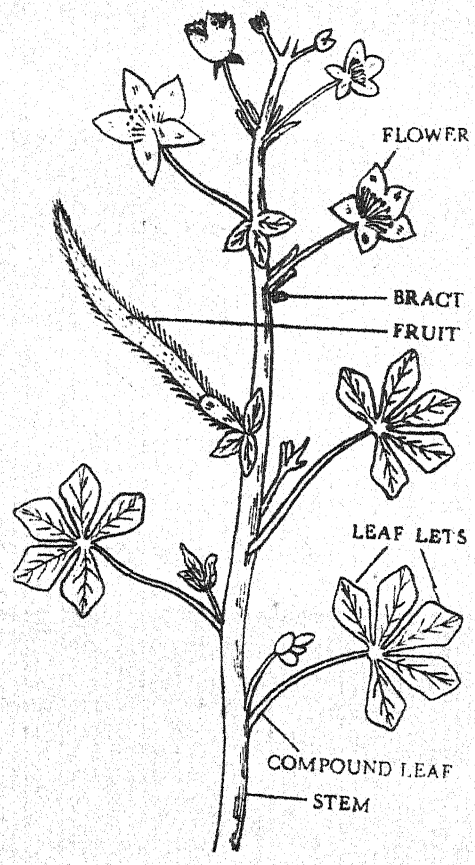
Sub-class—Polypetalae

Series—Thalamiflorae

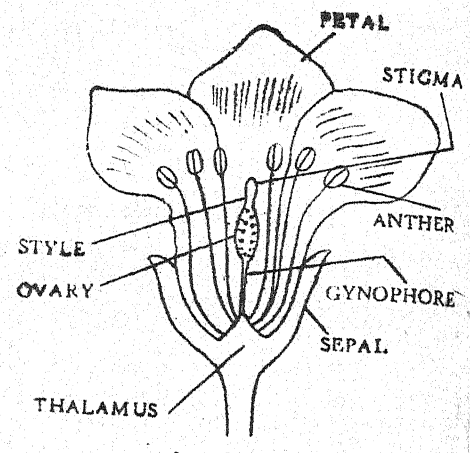
Order—Parietales

Family—Capparidaceae

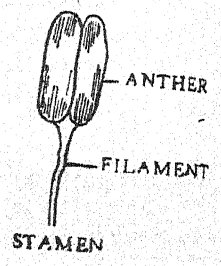
1. Leaves alternate 2. Gynophore, androphore present 3. Friut is capsule, berry or drupe.



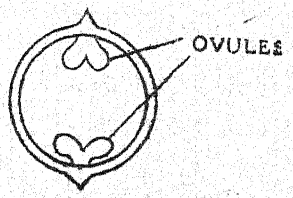
A FLOWERING TWIG



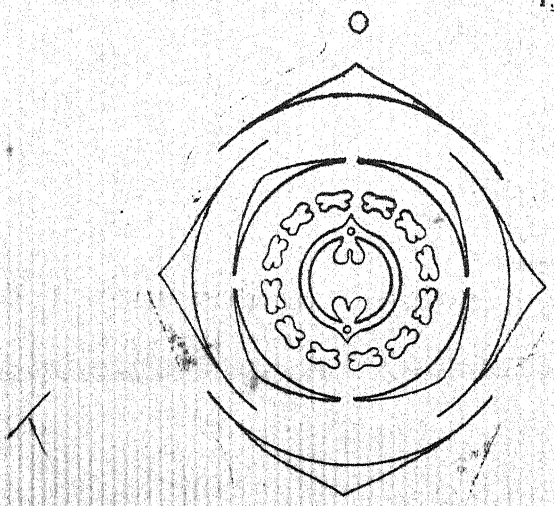
L. S. FLOWER



STAMEN



T. S. OVARY



FLORAL DIAGRAM

Fig. 191. *Cleome viscosa* (Capparidaceae)

Example 2. *Gynandropsis gynandra* (Hindi-Safed Hulhul).

Habit—Wild annul herb with peculiar odour.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, herbaceous, pubescent, so lid, green.

Leaf—Cauline, petiolate, palmately compound, pentafoliate, leaflet sessile, entire, obtuse or slightly acute, margin serrate, unicostate reticutate.

Inflorescence—Corymbose raceme.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorplic, hypogynous, white, tetramerous.

Calyx—Sepals 4, polysepalous, in two whorls of 2 each, imbricate.

Corolla—Petals 4, polypetalous, valvate, white.

Androecium—Stamens 6, polyandrous, filament long, anthers dithecous, dorsifixed, introrse, androphore present.

Gynoecium—Bicarpellary, syncarpous, unilocular, parictal placentation, many ovules, superior ovary, gynophore present, style short, stigma capitate and sticky.

Fruit—Capsule.

Floral Formula

$$Br,\ \oplus,\ \sigma^{\!\!\!

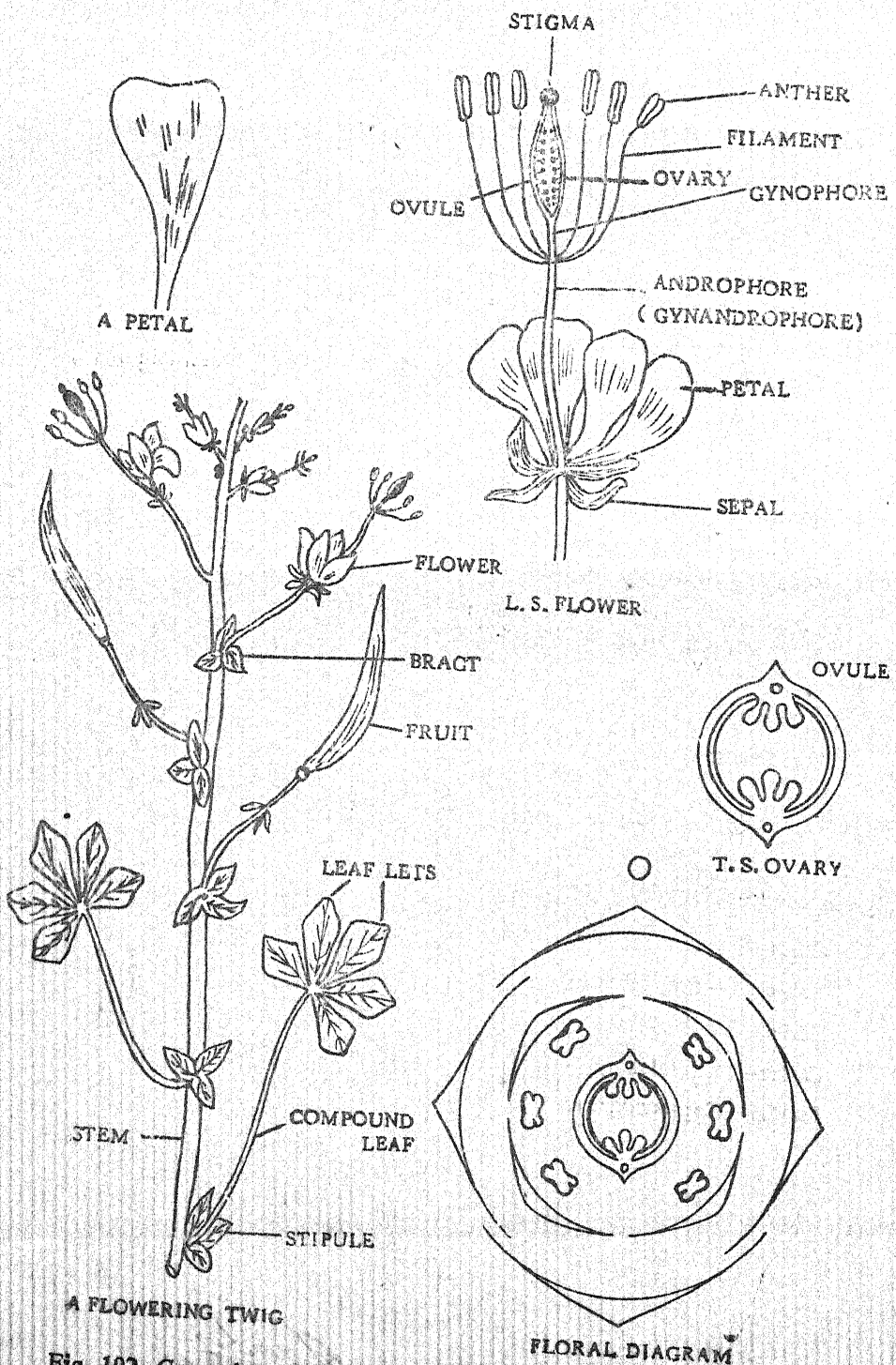


Fig. 192. *Gynandropsis gynandra* (Capparidaceae)

Example 3. *Capparis decidua* (Syn. *C. aphylla* ; Hindi-Kareel).

Habit—A perennial spiny bushy shrub.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, solid, spiny or thorny. green, old stems without leaves, photosynthetic.

Leaf—Cauline, simple, sessile or subsessile, stipulate, stipule spiny, leaf caducous, ovate, entire, acute to obtuse, unicostate reticulate.

Inflorescence—Corymb (1-3 flowered) on the laterals hoots.

Flower—Pedicellate, bracteate, complete, bisexual, zygomorphic, hypogynous, pinkish.

Calyx—Sepals 4, polysepalous, imbricate.

Corolla—Petals 4, polypetalous, imbricate, alternate to sepals, pinkish.

Androecium—Stamens six to indefinite, polyandrous, a rise from the base of the gynophore, filament long, anther dithecous, dorsifixed, introrse, androphore reduced or absent.

Gynoecium—Bicarpellary, syncarpous, unilocular, many ovules, parietal placentation, superior ovary, gynophore long, style short, stigma simple.

Fruit—Berry with many seeds.

Floral Formula

Br, %, ♂♀, K_2+_2, C_4, $A\infty$, $G(\underline{2})$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

Family—Capparidaceae

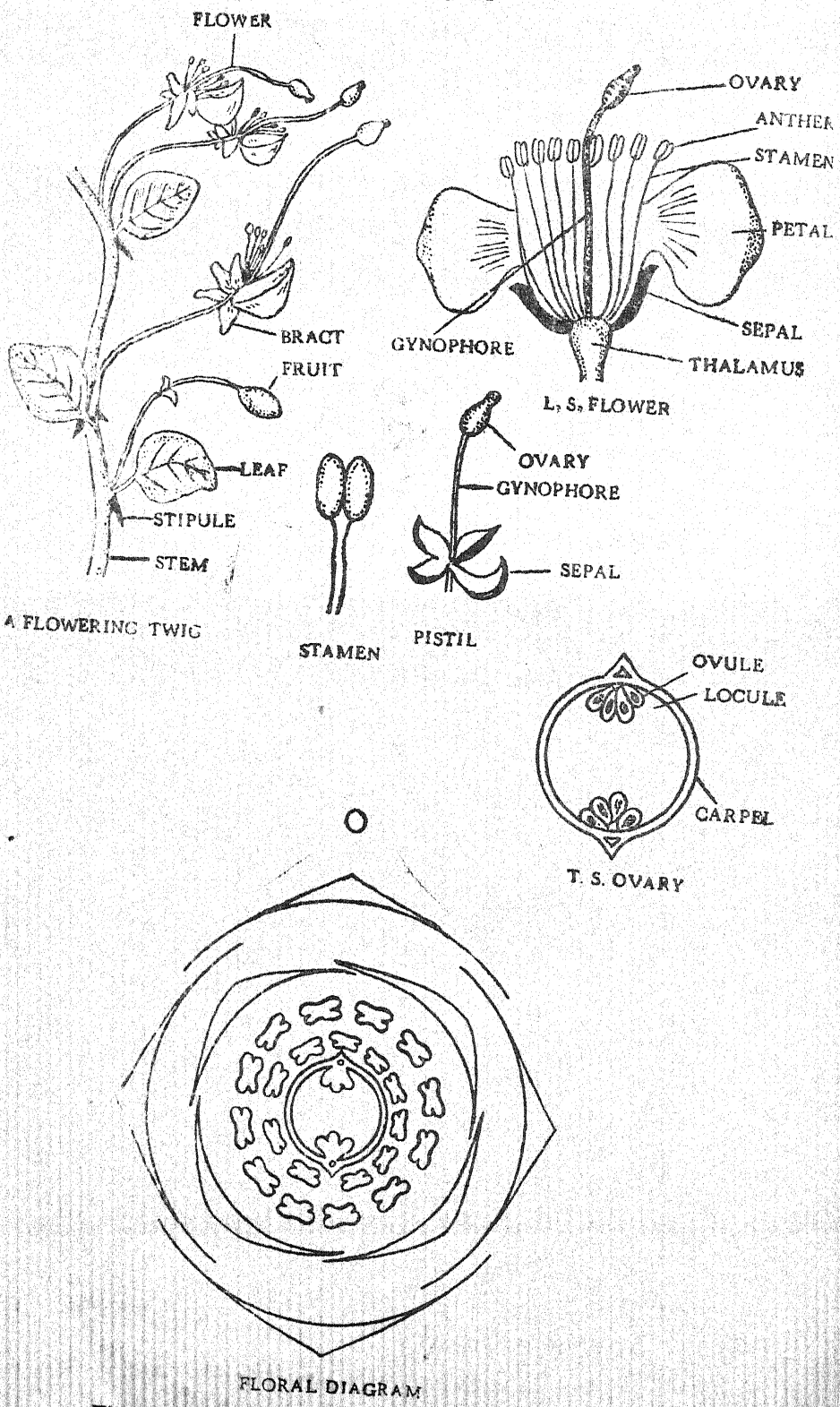


Fig.19 3. Capparis decidua (Capparidaceae)

PAPAVERACEAE

Example 1. *Papaver somniferum* (Opium poppy ; Hindi-Posta).

Habit—An annual herb, cultivated.

Root—Tap root, branched.

Stem—Aerial, erect, branched, herbaceous, cylindrical, hairy. fistular, green, milky latex present.

Leaf—Cauline, simple, alternate, sessile, exstipulate, margin dissected, tip acute, unicostate reticulate venation.

Inflorescence—Solitary terminal.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, hypogynous, bright red and showy.

Calyx—Sepals 2, polysepalous, caducous.

Corolla—Petals 4, polypetalous, in two whorls of 2 each, margin wavy, imbricate, bright red.

Androecium—Stamens indefinite, polyandrous, in several whorls filaments long, anther dithecous, basifixed, extrorse.

Gynoecium—Polycarpellary, syncarpous, unilocular (multilocular due to false septa), ovules indefinite, parietal placentation. style reduced, stigma persistent, red, discoid.

Fruit—Capsule.

Floral Formula

$$\oplus,\ \varphi^{\circlearrowright},\ K_2,\ C_2+_2,\ A\infty,\ \underline{G(\infty)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

Family—Papaveraceae

[1. Plants herbs, leaf exstipulate, latex present. 2. Calyx caducous 3. Flower actinomorphic, di or trimerous. 4. Stamens extrorse, carpels 2-16, fruit capsule].

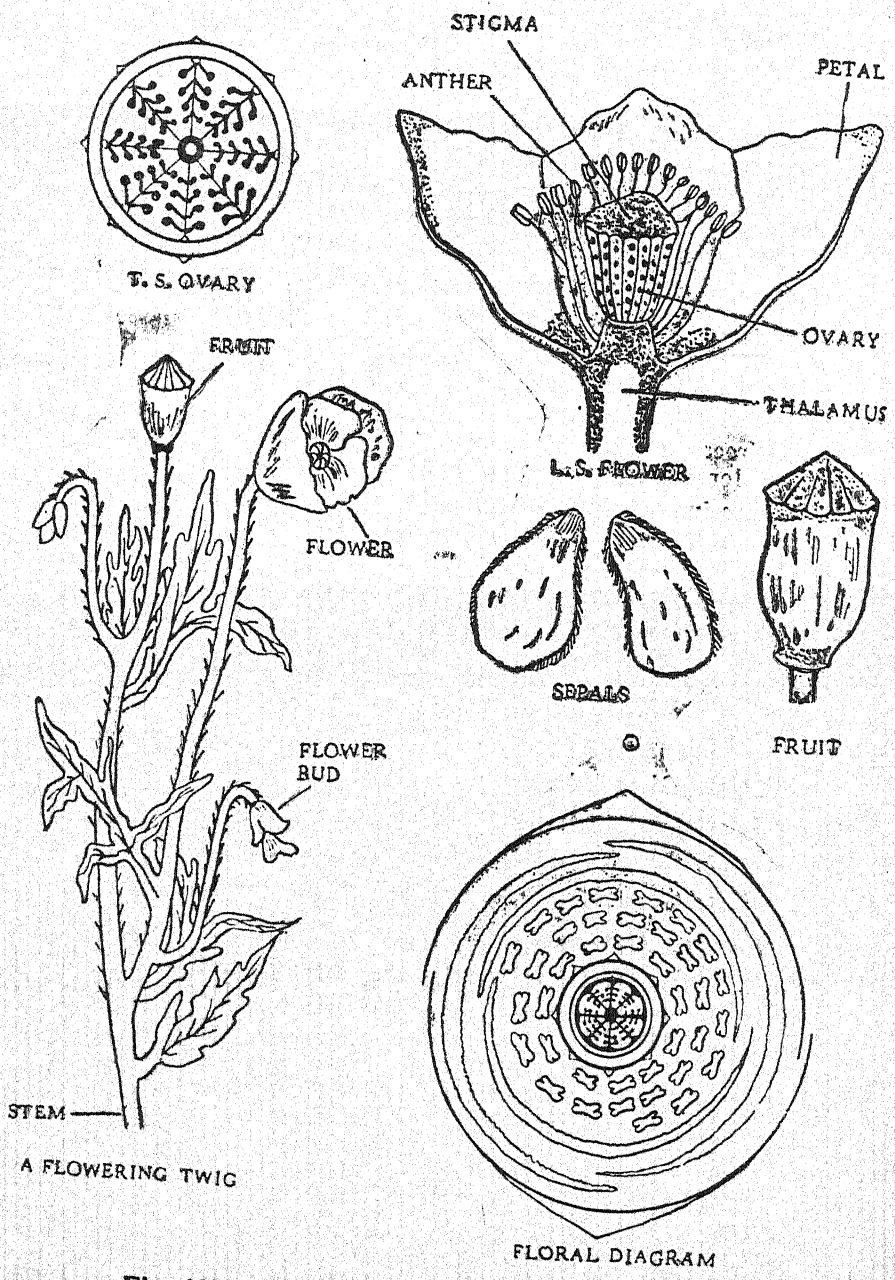


Fig. 193. *Papaver somniferum* (Papaveraceae)

Example 2. *Argemone mexicana* (Hindi-Pili katari)

Habit—An annul, wild prickly herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, glaucous, cylindrical, herbaceous, spiny, yellow latex present.

Leaf—Cauline, simple, sessile, alternate, exstipulate, deeply dissected (pinnatifid), margin toothed, tip acute, bluish green, spiny, multicostate reticulate venation, yellow latex present.

Inflorescence—Solitary axillary.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, hypogynous, yellow, yellow latex present.

Calyx—Sepals 3, polysepalous, prickly, twisted aestivation.

Corolla—Petals 6, polypetalous, in two whorls of 3 each, imbricate, caducous, yellow.

Androecium—Stamens indefinite, polyandrous, in several whorls, alternate with each other, filaments long, anthers dithecous, basifixed, extrorse.

Gynoecium—Carpels 5 (or 2—6), syncapous, unilocular, parietal placentation, several ovules on each placentum, superior ovary, style reduced, stigma 5 (or 2—6 as the number of the carpel), spines are present on the ovary.

Fruit—Capsule (spiny).

Floral Formula

$\oplus$, φ, K_3, C_3+_3, $A\infty$, $\underline{G(5)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

Family—Papaveraceae

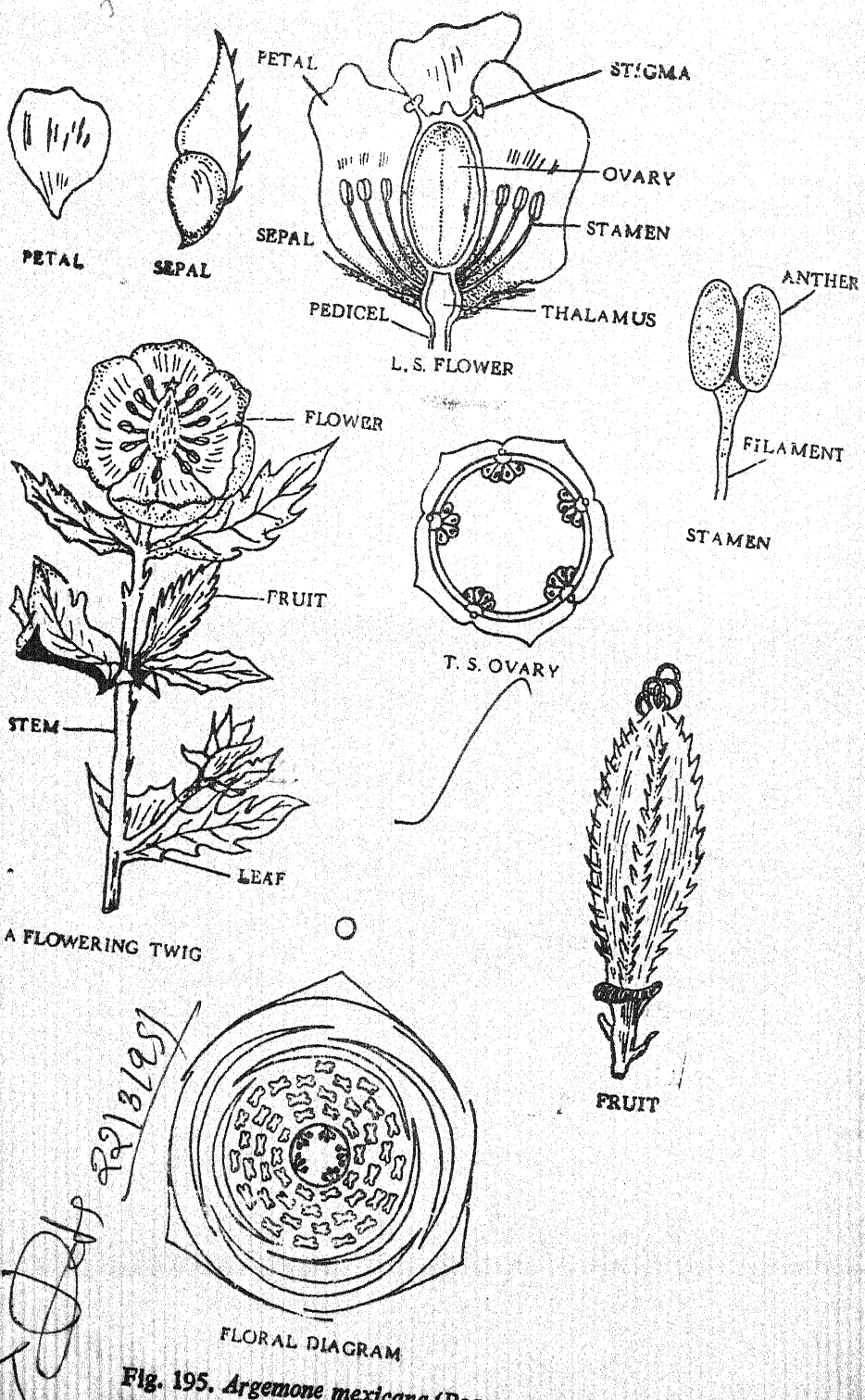


Fig. 195. ***Argemone mexicana*** **(Papaveraceae).**

Example 3. *Fumaria indica* Syn. *F. parviflora* (Hindi-Pit Papara).

Habit—A cultivated annual herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, herbaceous, glaucous, watery sap present.

Leaf—Cauline, simple, alternate, petiolate, exstipulate, deeply dissected, multicostate reticulate venation, watery juice present.

Inflorescence—Racemose.

Flower—Pedicellate, bracteate, complete, bisexual, zygomorphic, hypogynous, purple-pink.

Calyx—Sepals 2, polysepolous, small, lanceolate, membranous, placed anterioposteriorly, caducous.

Corolla—Petals 4, polypetalous, in 2 whorls of 2 petals each, outer petals large and one of the two outer petals is spurred, inner petals smaller and placed anterioposteriorly, purple-pink.

Androecium—Stamens in 2 groups, each group has 1/2 + 1 + 1/2 stamens, polyandrous, filament broad at base but narrow upward, one of the two groups of the stamens is also spurred (containing nectary) which fits into the spur of the petal, basifixed, extrorse.

Gynoecium—Bicarpellary, syncarpous, unilocular, ovules many, placentation parietal, ovary superior, style long, stigma bilobed.

Fruit—Cspsule.

Floral Formula

$$\text{Br, } \%, \ \delta\,♀, \ K_2, \quad C_2 + {}_2, \quad A_3 + {}_3, \quad \underline{G(2)}.$$

Systematic Position

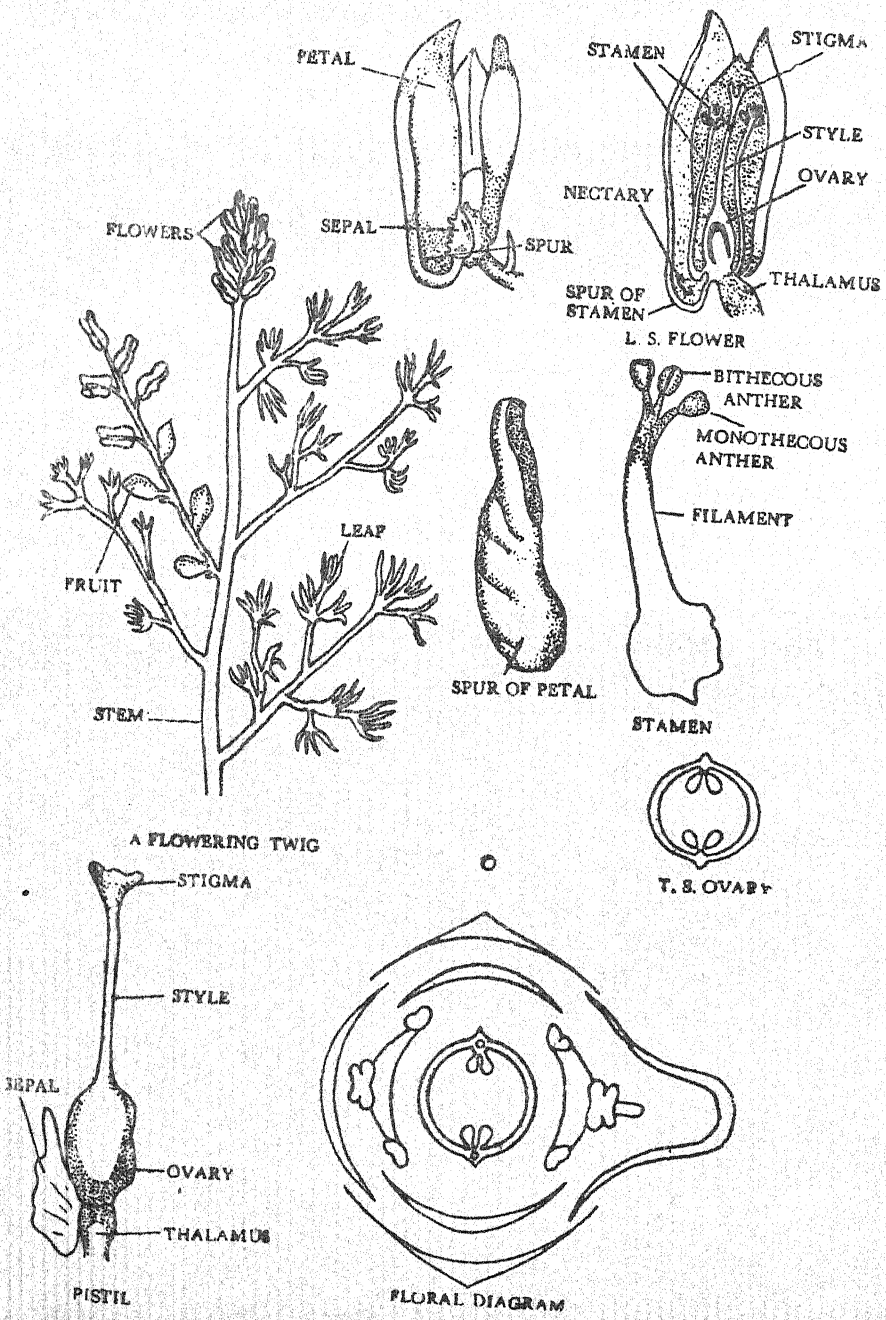
Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

Family—Papaveraceae



Fig, 196. ***Fumaria indica*** **(Papaveraceae)**

VIOLACEAE

Example 1. *Viola tricolor* (Garden pansy ; Hindi-Titli)

Habit—Cultivated annual herb.

Root—Tap root, branched.

Stem—Aerial, herbaceous, branched, angular, glabrous, fistular, green.

Leaf—Cauline, simple, alternate, petiolate, ovate, margin crenate, tip unicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, bract and bracteole present, complete, bisexual, zygomorphic, hypogynous, showy and butter-fly-like in appearance (many shades) usually violet with dark streaks.

Calyx—Sepals 5, polysepalous, imbricate, odd sepal posterior, appendiculate, persistent.

Corolla—Petals 5, polypetalous, imbricate, alternate to sepals, uneqnal, odd petal anterior and is suprred.

Androecium—Stamens 5, polyandrous, connate, in a ring, filaments small, anther dithecous, hairy, apical appendage present, adnate, 2 anterior stamens spurred and these spurs project into the spur of the anterior petal.

Gynoecium—Tricarpellary, syncarpous, unilocular, parietal placentation, ovules many, ovary superior, style short, stigma swollen.

Fruit—Capsule

Floral Formula

Br, %, ♂, ♀, K_5, C_5, A_5, G(3).

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Parietales

Family—Violaceae

[1. Plants herbs and flowers zygomorphic, pentamerous 2. Anterior petal spurred 3. Anther appendiculate 4. Tricarpellary, syncarpous, unilocular, parietal placentation, superior ovary.]

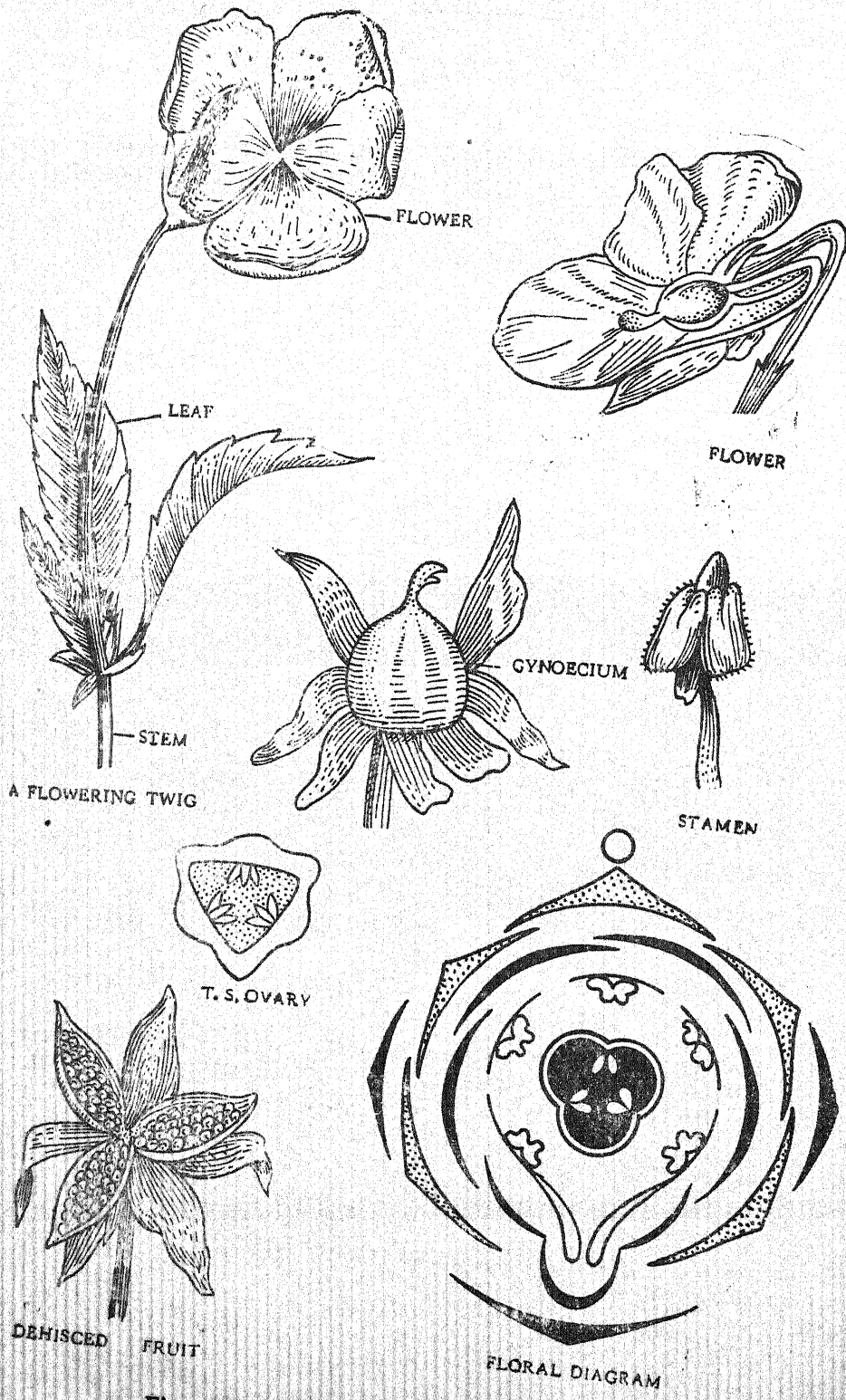


Fig. 197. ***Viola tricolor*** **(Violaceae)**

CARYOPHYLLACEAE

Example 1. *Dianthus caryophllus* (Carnation).

Habit—A cultivated annual herb.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, solid, glabrous, herbaceous, green, slightly swollen at nodes.

Leaf—Cauline, simple, sessile, opposite decussate, exstipulate, leaf-base sheathing, linear-lanceolate, entire, acute, unicostate reticulate, glabrous.

Inflorescence—Axillary or terminal dichasial cyme.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, actinomorphic, hypogynous, tubular, large, variously coloured.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, imbricate, calyx tubular.

Corolla—Petals 5, polypetalous, alternating with sepals, twisted, petals clawed, variously coloured.

Androecium—Stamens 10, in 2 whorls of 5 each, polyandrous, obdiplostemonous, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular, ovules many, free central placentation, ovary superior, style 2, free, stigma 2. Axila placentation in bud.

Fruit—Capsule

Floral Formula

$$\text{Br},\ \oplus,\ \varsigma^{\mathfrak{o}}_{+},\ K_{(5)},\ C_{5},\ A_{5}+_{5},\ \underline{G(2)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Caryophyllinae

[1. Stamens 5+5, obdiplostemonous.

2. Ovary unilocular and placentation free central.

3. In young flowers the ovary may be 2-5 carpellary, multilocular and placentation axile.]

Family—Caryophyllaceae

[1. Plants herbs 2. Leaves opposite decussate 3. Flowers in cymose paincles, flower bisexusl and actinomorphic. 4. Ovary 2-5 carpellary, unilocular, placentation free central. 5. Fruit capsule or berry].

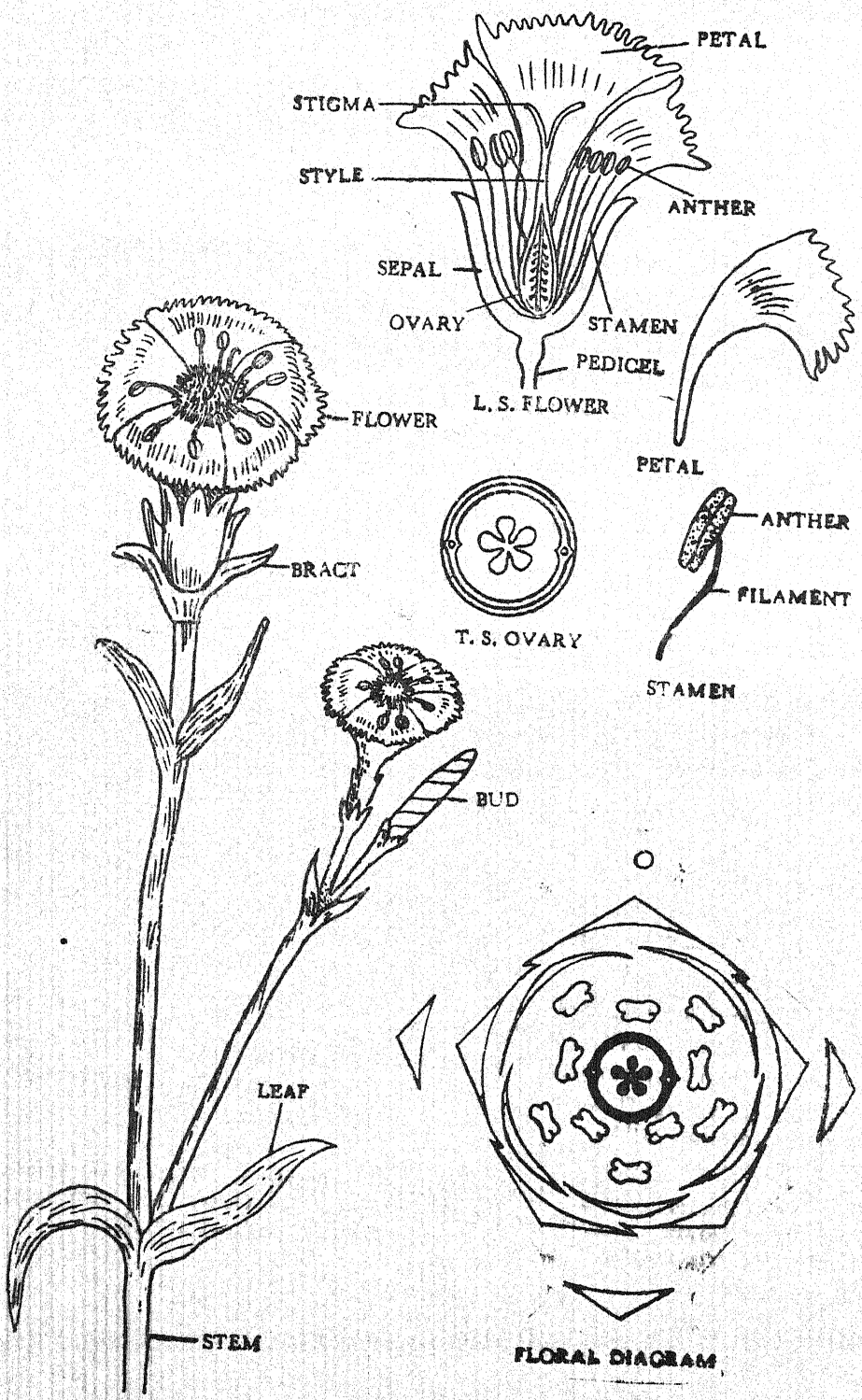


Fig. 198. *Dianthus caryophyllus* (Caryophyllaceae)

Example 2. *Saponaria vaccaria* Syn. *S. officinalis* (Soapwort)

Habit—A cultivated annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, glabrous, slightly swollen at nodes.

Leaf—Cauline, simple, sessile, exstipulate, opposite decussate, linear-lanecolate, entire, acute, unicostate reticulate.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, 1 bract and 2 bracteoles, complete, bisexual, actinomorphic, hypogynous, pink.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, imbricate, tubular, persistent.

Corolla—Petals 5, polypetalous, clawed, alternating to sepals, twisted, pink.

Androecium—Stamens 10, 5+5, polyandrous, obdiplostemonous, inserted on short gynophore, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Bricarpellary, syncarpous, unilocular, free-central placentation, many ovules, ovary superior, thalamus expanded forming a shor gynophore, style 2, stigma 2, simple. In bud placentation is axile.

Fruit—Capsule, covered by calyx tube.

Floral Formula

$$Br,\quad \oplus,\quad \varsigma^{\mathfrak{o}}_{\mathfrak{+}},\quad K_{(5)},\quad C_{5},\quad A_{5}+_{5}\quad \underline{G(2)}.$$

Systematic Position.

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Caryophyllinae

Family—Caryophyllaceae

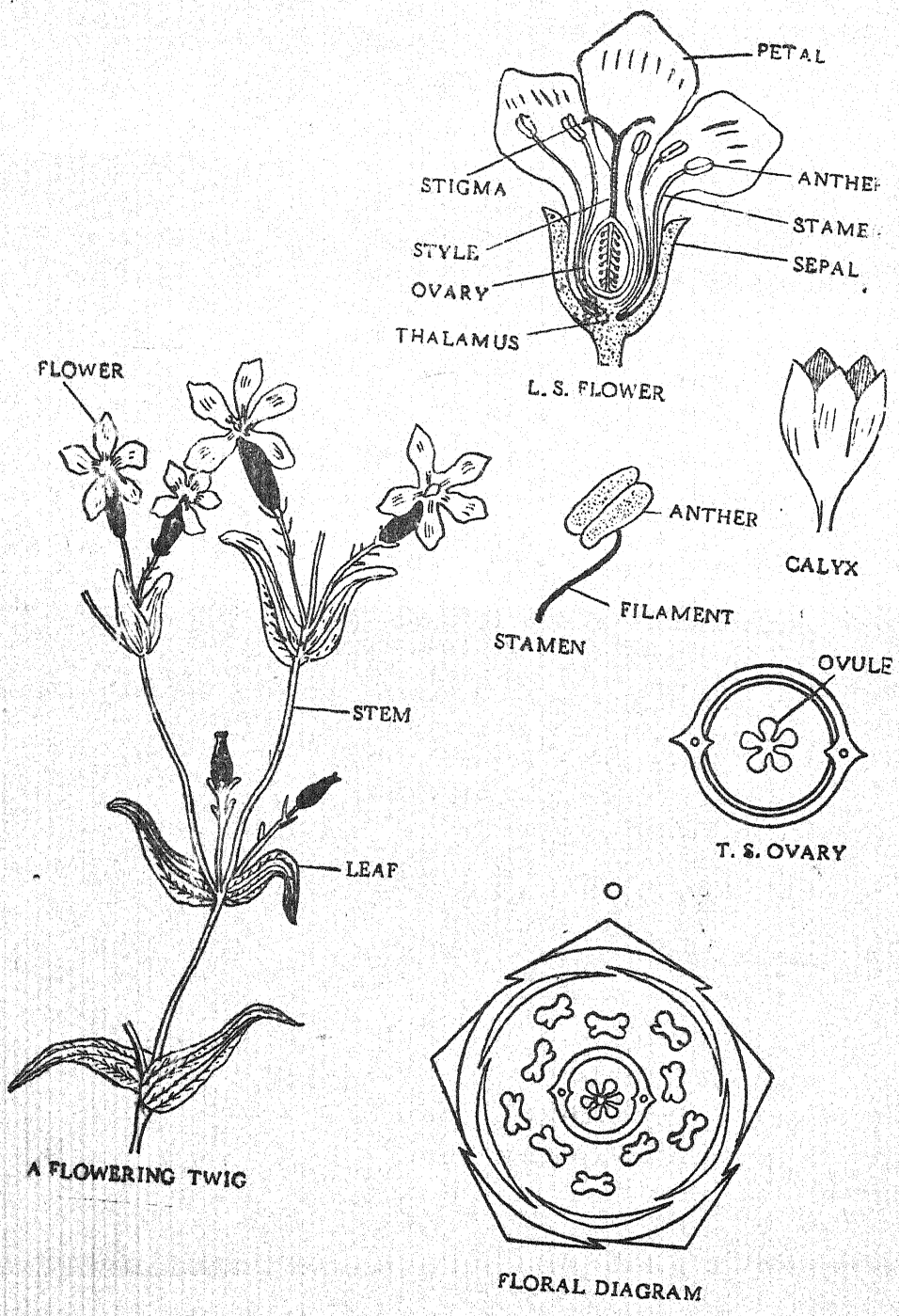


Fig. 199. ***Saponaria vaccaria*** **(Caryophyllaceae)**

Example 3. *Stellaria media* (Stichwort ; Hindi-Gandal)

Habit—An annual wild herb.

Root—Branched taproot.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, flaccid, hairy, green.

Leaf—Lower leaves petiolate but upper leaves sessile, exstipulate, opposite decussate, simple, ovate-lanceolate, entire, acute, unicostate reticulate.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, 1 bract and 2 bracteoles, complete, bisexual, actinomorphic, hypogynous, white.

Calyx—Sepals 5, polysepalous, odd sepal postelor, imbricate aestivation.

Corolla—Petals 5, polypetalous, alternate to sepals, deeply bilobed, shorter than sepals, imbricate, white.

Androecium—Stamens 5 (but may be more than 5, upto 10), polyandrous, filament short, anther dithecous, dorsifixed, introrse.

Gynoecium—Tricarpellary, syncarpous, unilocular, free-central placentation, superior ovary, ovules many, thalamus hairy, style reduced, stigma 3

Fruit—Capsule.

Floral Formula

Br, $\oplus$, $\overset{\circ}{\underset{\male}{\varphi}}$, K_5, C_5, A_∞, $\underline{G_{(3)}}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Caryophyllinae

Family—Caryophyllaceae

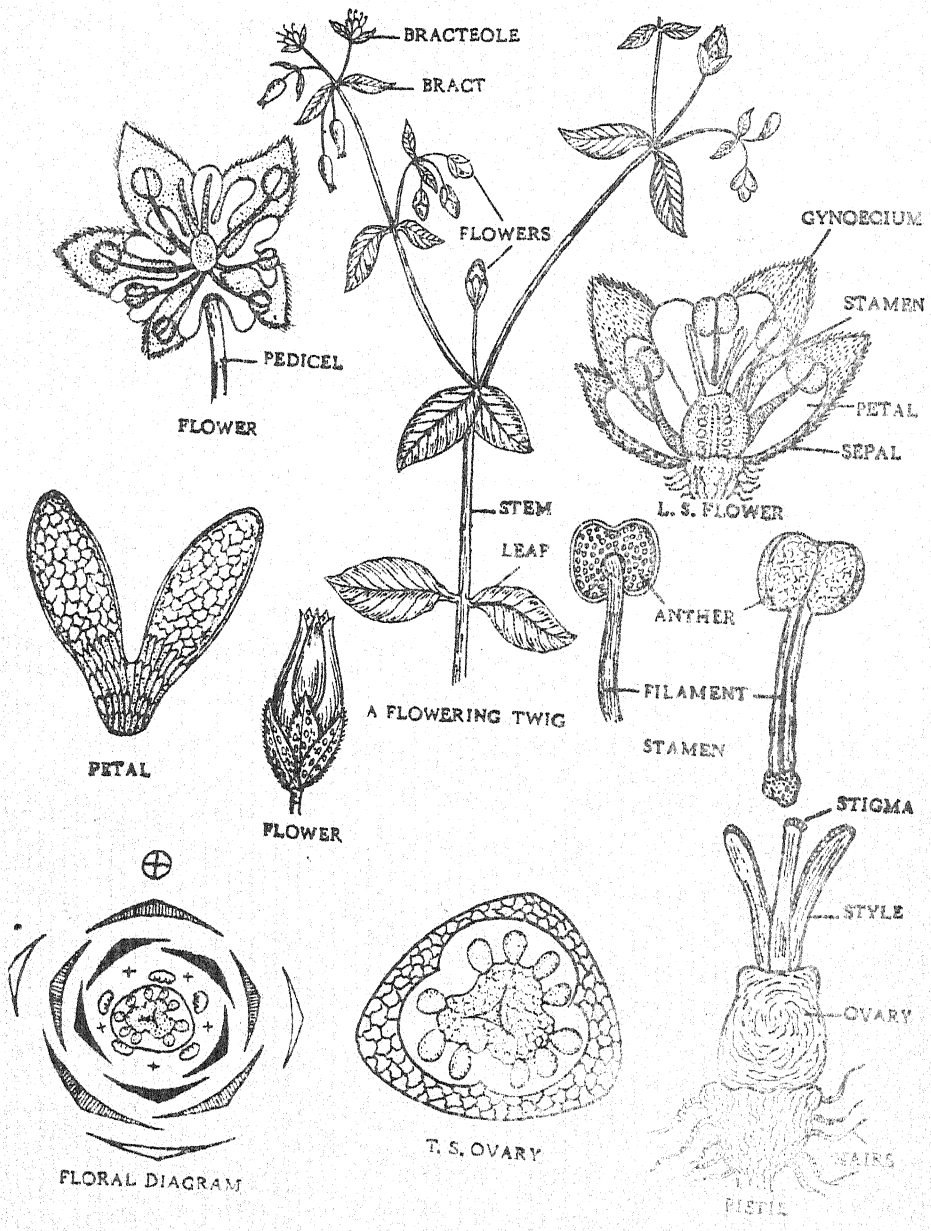


Fig. 200 ***Stellaria media*** **(Caryophyllaceae)**

Example 4. *Spergula arvensis* (Corn spurrey)

Habit—An annual wild herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, glabrous.

Leaf—Cauline, apparently whorled, sessile, stipulate, stipules small and scarious, linear-acicular, entire, acute, unicostate reticulate venation.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, 1 bract and 2 bracteoles, complete, bisexual, actinomorphic, hypogynous, small, white, pentamerous, cyclic.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate, persistent.

Corolla—Petals 5, polypetalous, alternate with sepals, twisted.

Androecium—Stamens 10, in two whorls of 5 each, polyandrous, obdiplostemonous, filament short, anther dithecous, dorsifixed, introse, glands present at the base of each stamen.

Gynoecium—Pentacarpellary, syncarpous, unilocular, free-central placentation, many ovules, ovary superior, style 5, free, stigma 5, simple (some times carpel 3, style 3, stigma 3).

Fruit—Capsule

Floral Formula

$$Br,\ \oplus,\ \overset{\text{♂}}{\text{♀}},\ K_5,\ C_5,\ A_5+_5,\ G\ \underline{(5)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Caryophyllinae

Family—Caryophyllaceae

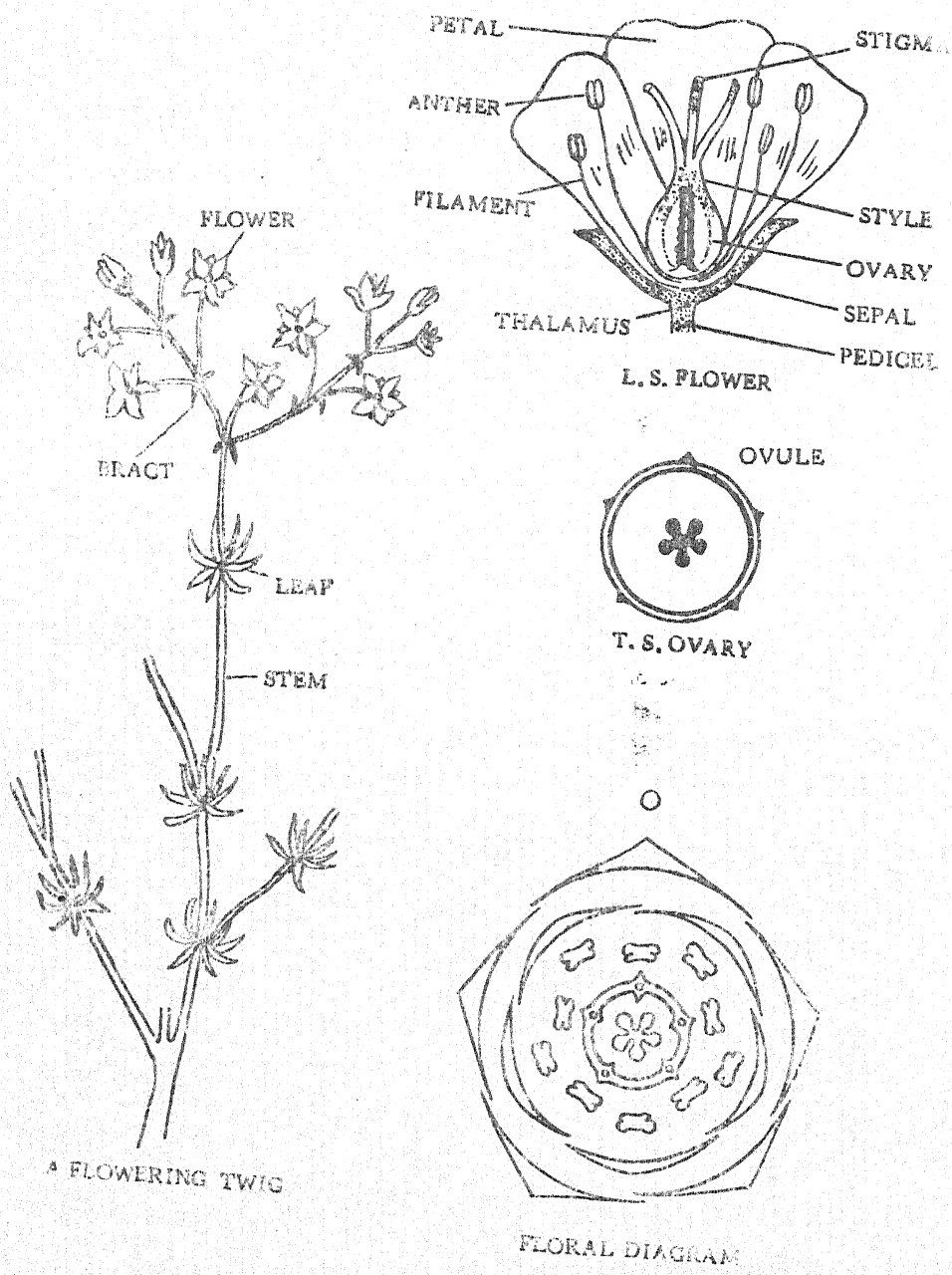


Fig. 201 ***Spergula arvensis*** **(Caryophyllaceae)**

MALVACEAE

Example 1. *Hibiscus rosa-sinensis* (Shoe flower ; Hindi-Gurhal)

Habit—A cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid, glabrous, upper stem green.

Leaf—Cauline, petiolate, stipulate, simple, alternate, ovate, margin serrate, tip acute, glabrous, unicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, ebracteate, complete, bisexual, actinomorphic, hypogynous, cyclic.

Epicalyx—5-8, jointed at base, valvate.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, polypetalous, alternate to sepals, monadelphous (united to form one bundle, staminal tube) entire, jointed to petals, filament short, anther monothecous, basifixed, reniform, extrorse.

Gynoecium—Pentacarpellary, syncarpous, pentalocular, axile placentation, many ovules in each locule, superior ovary, style long, passes through staminal tube, stigma 5, knobed.

Fruit—Capsule.

Floral Formula

Br, $\oplus$, $\overset{\circlearrowleft}{+}$, Epi (5-8), K_5, C_5 $\widehat{A\infty}$, $\underline{G(5)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Malvales

[1. Stamens indefinite, monadelphous, staminal tube. 2. Ovary 3—∞ carpellary, placentation axile.]

Family—Malvaceae

[1. Leaves stipulate 2. Epicalyx present 3. Anthers monothecous and reniform 4. Fruit capsule or schizocarpic].

Sushil Kumar Purbar

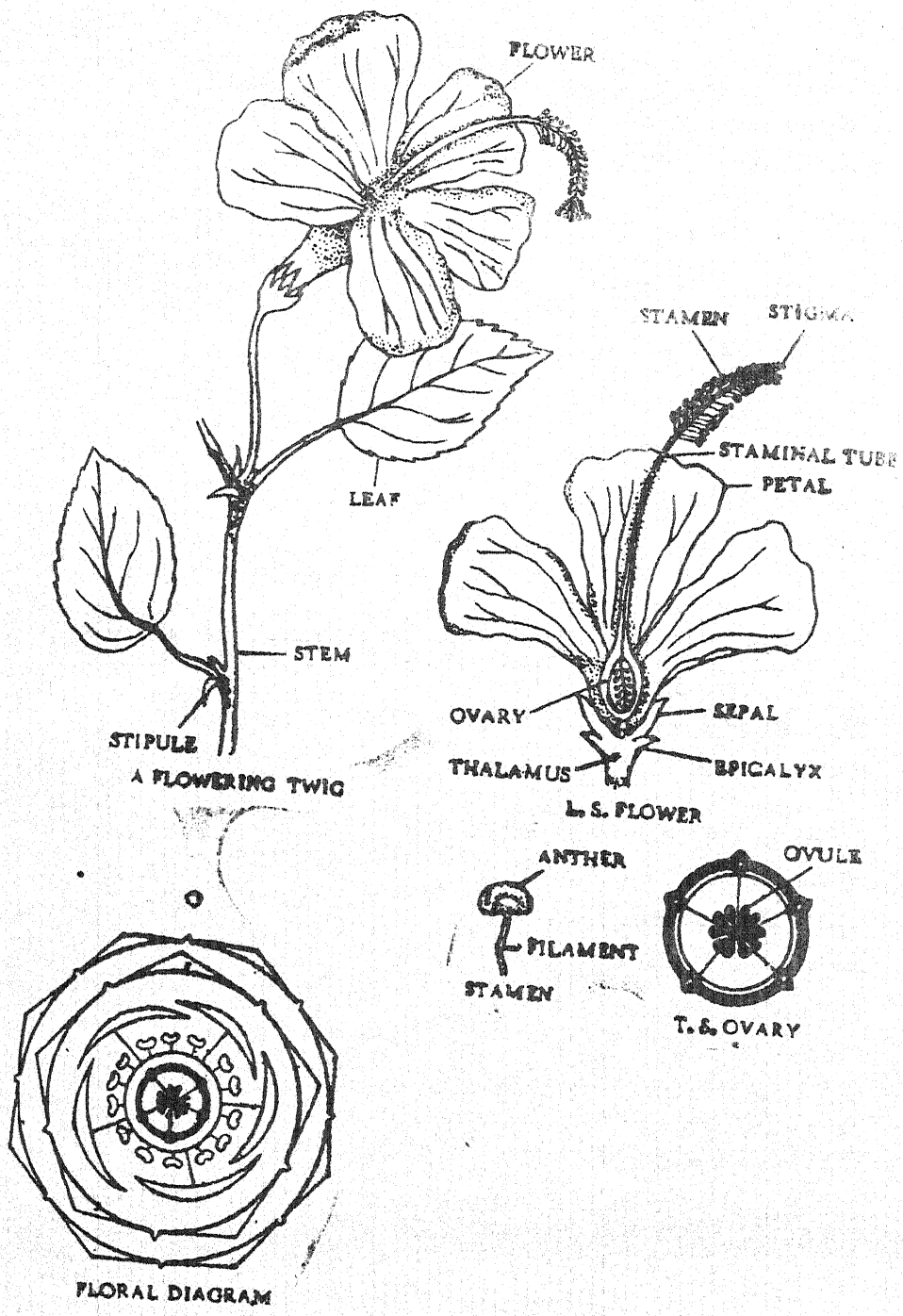


Fig. 202. *Hibiscus rosa-sinensis* (Malvaceae)

Example 2. *Sida cordifolia* (Hindi-Bal)

Habit—An annual herb, wild.

Root—Branched tap root.

Stem—Aerial, erect, beanched, cylindrical, woody, solid, glabrous, brownish.

Leaf—Cauline, petiolate, petiole short, simple, stipulate, ovate, margin dentate, tip obtuse to slightly acute, unicostate reticulate venation.

Inflorescence—Axillary cymose.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorphic, regular, pentamerous, hypogynous, dirty yellow coloured.

Epicalyx—Absent.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, polypetalous, alternating to sepals, twisted.

Androecium—Stamens indefinite, monadelphous, staminal tube present, epipetalous, filament short, anther monothecous, reniform, basifixed, extrorse.

Gynoecium—Pentacarpellary, syncarpous, pentalocular, axile placentation, many ovules in each locule, ovary superior, style long, as many as carples, style passes through staminal tube, stigma branched, capitate.

Fruit—Carcerulus.

Floral Formula

Br, $\oplus$, $\overset{\circlearrowleft}{\varphi}$, Epi_0, K (5), C5, A∞, G (5).

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Malvales

Family—Malvaceae

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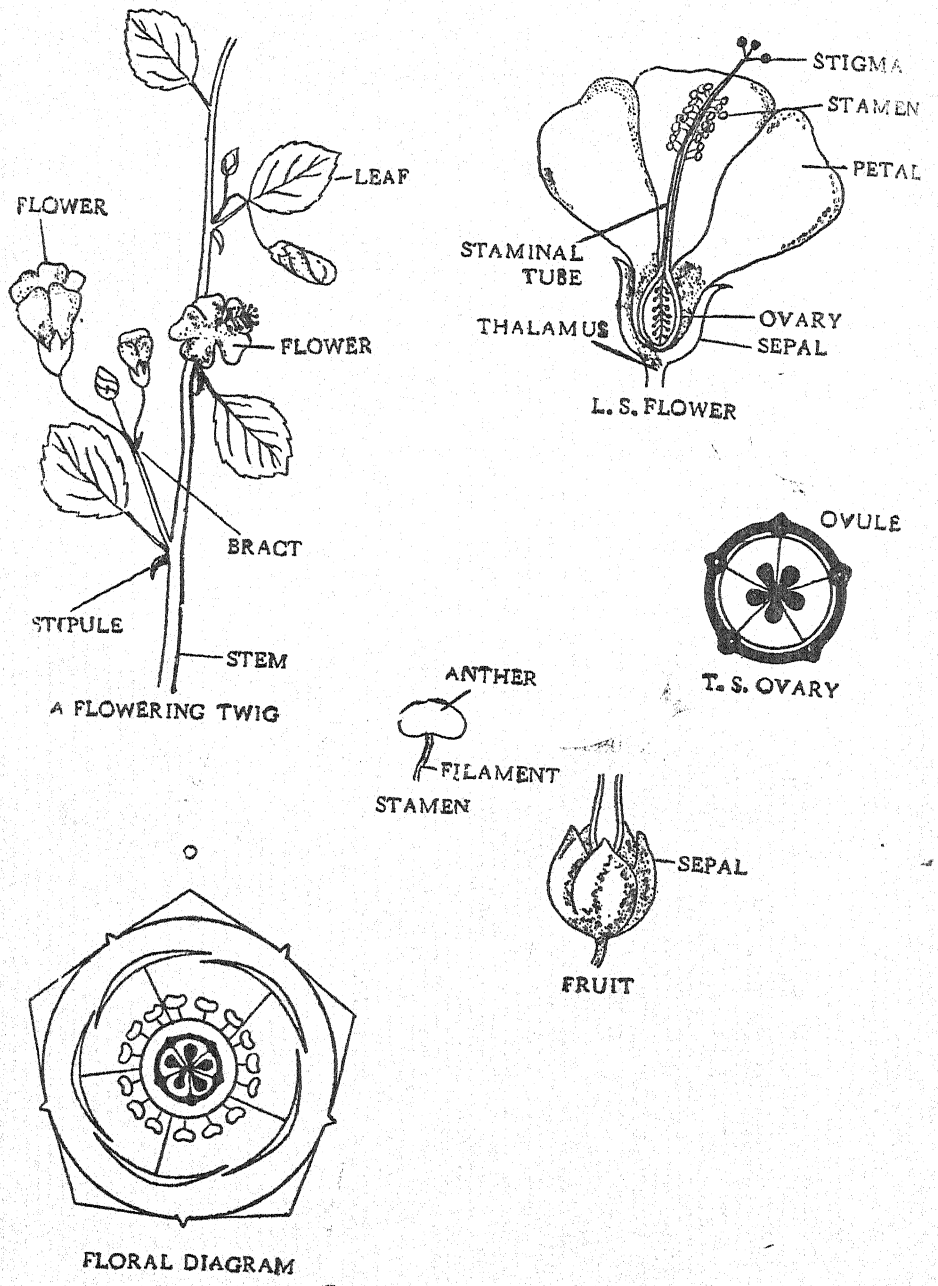


Fig. 203. *Sida cordifolia* (Malvaceae)

Example 3. *Malva sylvestris* (*Mallow*)

Habit—A cultivated annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, herbaceous above and woody below, solid, hairy, green.

Leaf—Cauline, petiolate, simple, stipulate, alternate, hairy (lower surface), ovate, margin crenate, tip acute, unicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorphic, regular, pentamerous, hypogynous, yellow.

Epicalyx—3, jointed at base.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, persistent, bell shaped, valvate.

Corolla—Petals 5, polypetalous, alternating to sepals, twisted, united at base with staminal tube.

Androecium—Stamens indefinite, monadelphous, form staminal tube, epipetalous, filament short, anther monothecous, reniform, basifixed, extrorse.

Gynoecium—Pentacarpellary, syncarpous, pentalocular, axile placentation, many ovulus in each locule, superior ovary, style 5, pass through the staminal tube, stigma 5 each bilobed and linear.

[Note—Carpels may be indefinite.]

Fruit—Capsule

Floral Formula

Br, $\oplus$, , Epi$_{(3)}$, K$_{(5)}$, C$_5$, A (∞), G$_{(5)}$

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

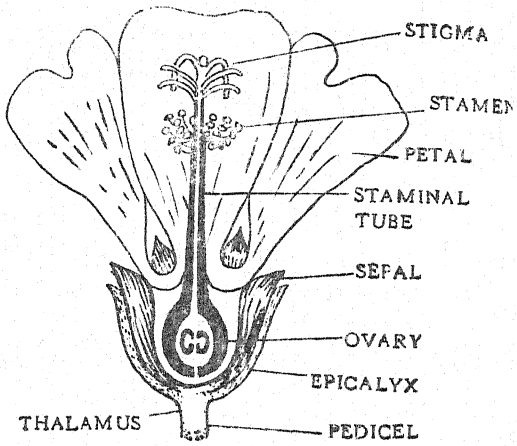
Series—Thalamiflorae

Order—Malvales

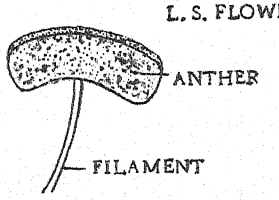
Family—Malvaceae



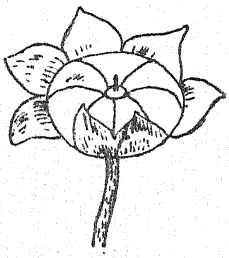
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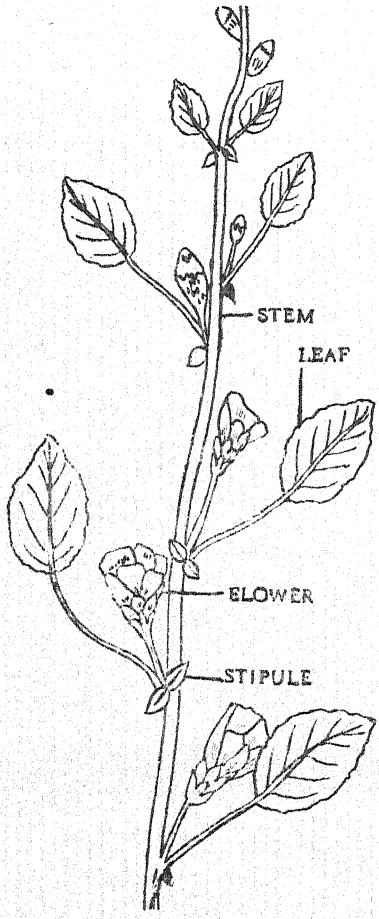
L. S. FLOWER



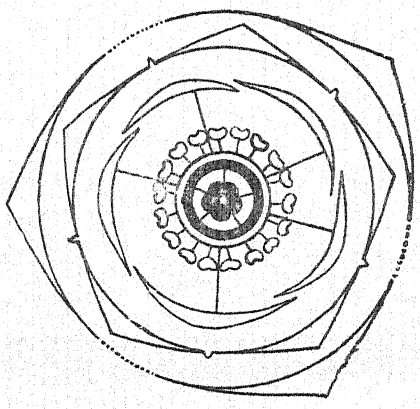
STAMEN



FRUIT



A FLOWERING TWIG



FLORAL DIAGRAM

Fig. 204. *Malva sylvestris*. (Malvaceae)

Example 4. *Althaea rosea* (Hollyhock ; Hindi—Gulkhaira)

Habit—A cultivated shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindricial, woody, solid, brownish, green, glabrous.

Leaf—Cauline, simple, alternate, petiolate, stipulate, ovate to cordate, margin lobed, unicostate reticulate venation.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorphic, pentamerous, hypogynous, variously coloured.

Epicalyx—6–9, joined at base.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate, bell-shaped.

Corolla—Petals 5, polypetalous, twisted, fused at the base of staminal tube.

Androecium—Stamens indefinite, monadelphous, form staminal tube, tube entire, epipetalous, filament short, anther monothecous, reniform, basifixed, extrorse.

Gynoecium—Pentacarpellary (may be indefinite), pentalocular, axile placentation, many ovules in each locule, styles as many as carpels, long, pass through the staminal tube, stigma lobed.

Fruit—Capsule.

Floral Formula

$$\text{Br}, \oplus, \mathrm{\sigma\!\!+}, \text{Epi } (6\text{—}9), \text{K}_{(5)}, \text{C}_{5}\,\widehat{\text{A}_{(\infty)}}, \underline{\text{G}_{(5)}}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Thalamiflorae

Order—Malvales

Family—Malvaceae

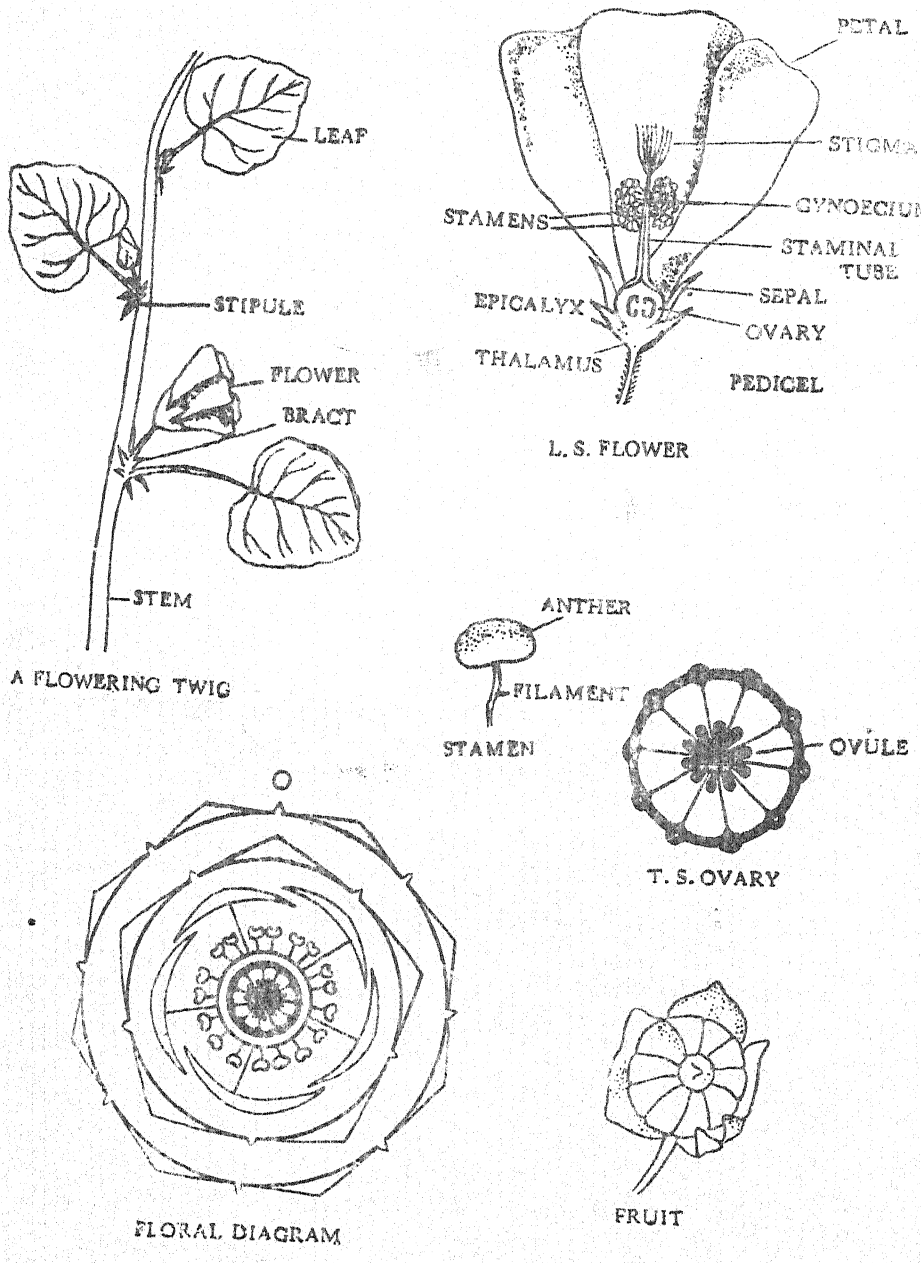


Fig. 205. *Althaea rosea* (*Malvaceae*)

Example 5. *Abutilon indicum* (Hindi-Kanghee)

Habit—A perennial wild undershrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, hairy, green.

Leaf—Petiolate, simple, alternate, stipulate, ovate, dentate, acute, unicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorphic, regular, cyclic, pentamerous, hypogynous, yellow.

Epicalyx—Absent.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, polypetalous, alternating to sepals, twisted, fused at the base of the staminal tube, yellow.

Androecium—Stamens indefinite, monadelphous, forming staminal tube, epipetalous, filament short, anthers monothecous, reniform. dorsifixed, extrorse.

Gynoecium—Pentacarpellary or indefinite, syncarpous, pentalocular, axile placentation, ovary superior, many ovules in each locule, style 5, stigma 5, lobed.

Fruit—Capsule.

Floral Formula

$$\text{Br},\ \oplus,\ \mathrm{\overset{\sigma}{\underset{+}{}}},\ \mathrm{Epi}_0,\ \mathrm{K}(5),\ \mathrm{C}5,\ \overset{\frown}{\mathrm{A}}(\infty),\ \underline{\mathrm{G}(5)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Thalamiflorae

Order—Malvales

Family—Malvaceae

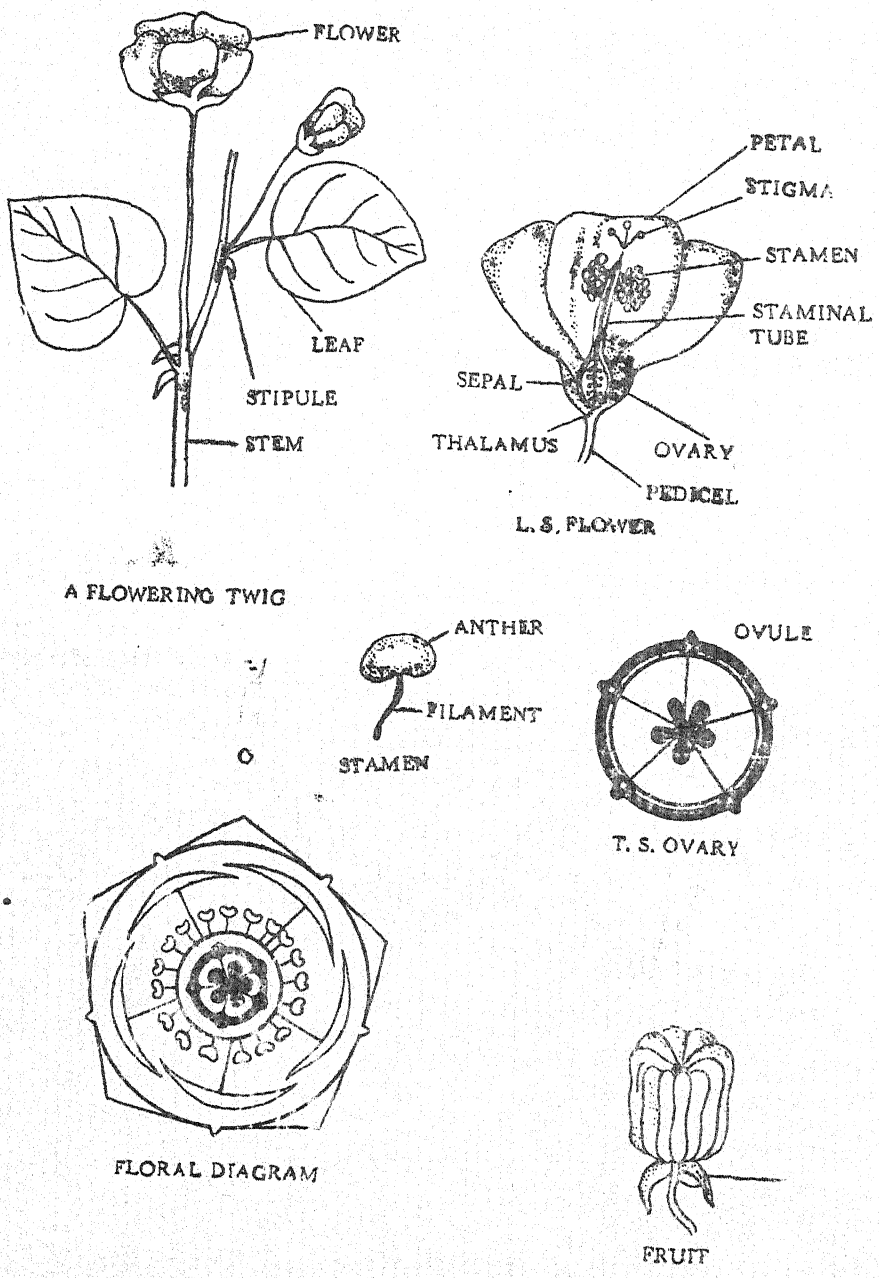


Fig. 206. ***Abutilon Indicum*** **(Malvaceae)**

RUTACEAE

Example 1. *Citrus medica* (Lemon ; Hindi—Nimboo)

Habit—A cultivated perennial tree.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, sparsely spiny, green.

Leaf—Cauline, petiolate, petiole winged, alternate, exstipulate, palmately compound, unifoliate, elliptic-lanceolate, crenate, acute, some times obtuse, glabrous, dotted glands present, unicostate reticulate.

Inflorescence—Axillary umbellate cyme.

Flower—Pedicellate, bracteate, bracteolate, caducous, complete, bisexual, actinomorphic, regular, cyclic, pentamerous (or tetramerous), hypogynous, white.

Calyx—Sepals 5 or 4, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5 or 4, polypetalous, alternating to sepals, imbricate, white.

Androecium—Stamens indefinite, whorled, polyadelphous, attached to the disc, filaments united at base, anthers long, dithecous, basifixed, introrse.

Gynoecium—Polycarpellary, syncarpous, polylocular, axile placentation, several ovules on each placentum, superior ovary placed on a honeydisc, style 1, stout, stigma 1 capitate.

Fruit—Hesperidium

Floral Formula

Br, ⊕, ♂, ♀, K (5) or (4), C 5 or4, A ∞ (Polyad), G(∞).

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Thalamiflorae

Order—Geraniales

[1. Disc annular, adnate to stamen or reduced to glan2. Ovaryds multicarpellary, syncarpous, axile placentation 3. Ovules pendulous, raphe ventral].

Family—Rutaceae

[1. Leaves winged, exstipulate, oil glands present 2. Stamens polyadelphous. 3. Honey disc annular 4. Fruit hesperidium.]

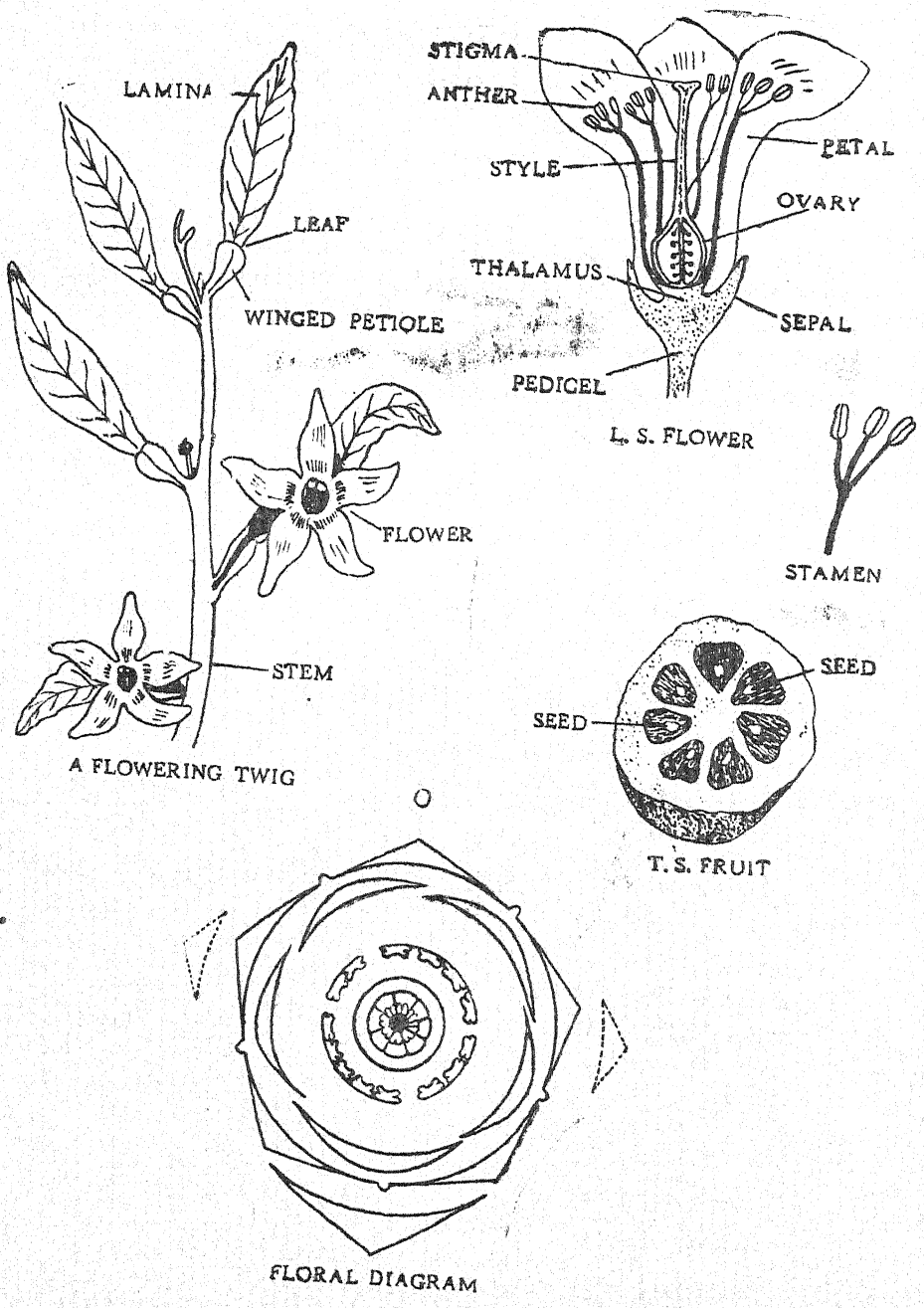


Fig. 207. *Citrus medica* (Rutaceae)

Example 2. *Murraya paniculata* Syn. *M. exotica* (Hindi-Kamini)

Habit—A cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid, herbaceous, hairy, green.

Leaf—Cauline, compound, petiolate, exstipulate, alternate, unipinnate, imparipinnate, leaflet petiolulate, elliptic-lanceolate, entire, obtuse, glaucous, unicostate reticulate, aromatic oil glands present.

Inflorescence—Dichasial cyme, some times solitary.

Flower—Pedicellate, bracteate, complete, bisexual, actinomorphic, pentamerous, cyclic, hypogynous, white.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, polypetalous, alternating to sepals, imbricate, fragrant, white.

Androecium—Stamens 10, tn two groups of 5 each, polyandrous, filament thick, flat, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation, one ovule in each locule, superior ovary, ovary placed on a honey disc, style thick, stigma capitate, bilobed, sticky.

Fruit—Berry

Floral Formula

Br, ⊕, ♂♀, K (5), C5, A 5+5, G (2̲).

Systematic Position

Class—Dicotyledons

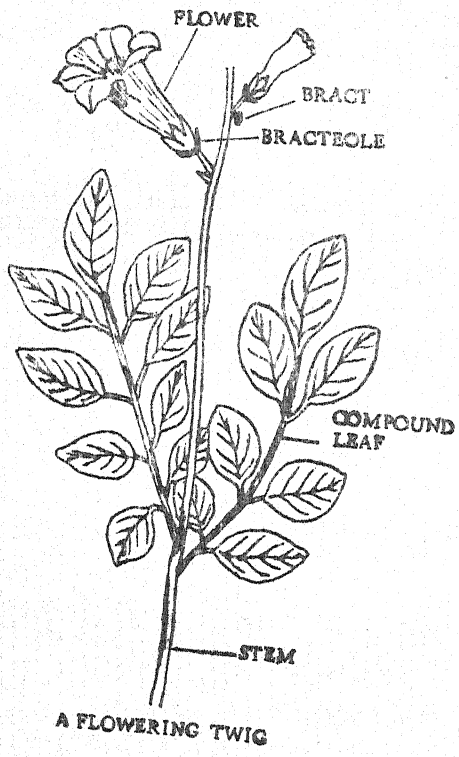
Sub-Class—Polypetalae

Series—Thalamiflorae

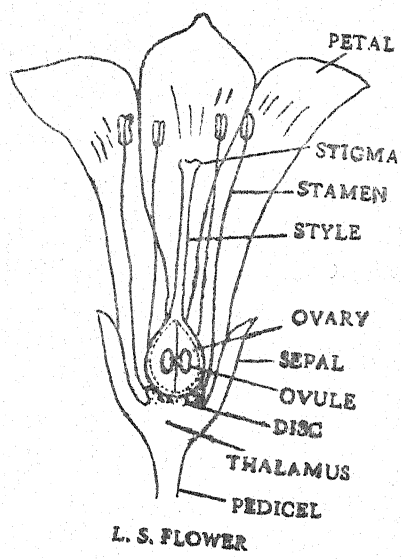
Order—Geraniales

Family—Rutaceae

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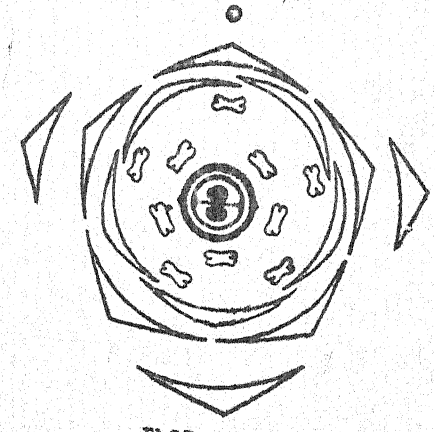
A FLOWERING TWIG



L. S. FLOWER



T. S. OVARY



FLORAL DIAGRAM

Fig. 208. *Murraya paniculata* (Rutaceae)

PAPILIONACEAE (PAPILIONATAE) OR FABACEAE

Example 1. *Pisum sativum* (Pea ; Hindi-Matar)

Habit—A cultivated annual herb.

Root—Branched tap root, root nodules present.

Stem—Climber, aerial, branched, cylindrical, herbaceous, hairy, green,y fistular, branches terminate into tendrils.

Leaf—Cauline, petiolate, compound, stipulate, stipules leafy, leaf alternate, imparipinnate, upper leaflets modified into tendrils, leaflets sessile, ovate, entire or slightly dentate, acute, glabrous, unicostate reticulate.

Inflorescence—Axillary cymose.

Floewer—Pedicellate, bracteate, complete, bisexual, irregular, zygomorphic, pentamerous, cyclic.

Calyx—Sepals 5, polysepalous, odd sepal anterior, valvate, slightlfused at base only.

Corolla—Petals 5, polypetalous, papilionaceous, i.e. a large *standard*, posteriorly placed, 2 lateral *wings* and two anteriorly placed small petals which fuse to form a *keel*, aestivation descending imbricate.

Androecium—Stamens 10, diadelphous, (9) +1, form staminal tube, staminal tube truncate, filament long, anther dithecous, basifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, ovary semi-inferior, style 1, long and curved, stigma capitate.

Fruit—Legume or Pod.

Floral Formula

Br, %, ♀♂, K5, C5, or 1+2 + (2), A (9) +1, G_1—.

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Calyciflorae

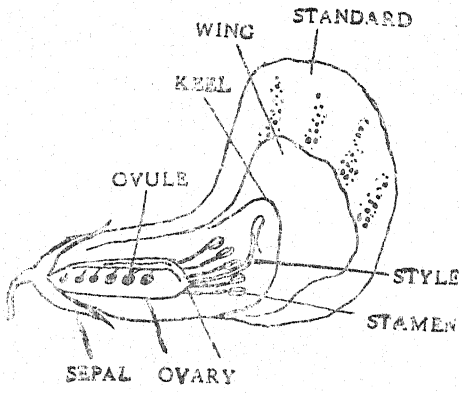
[1. Thalamus shows depression. 2. Ovary inferior or half-inferior]

Order—Rosales.

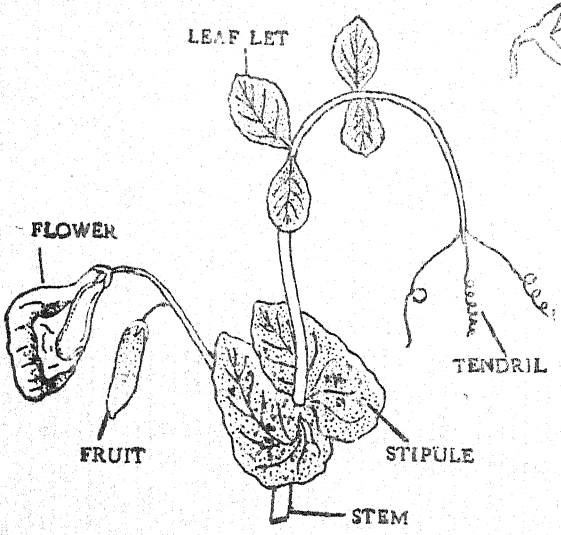
[1. Leaves stipulate, alternate. 2. Carpel one or more].

Family—Papilionaceae (Fabaceae)

[1. Flowers zygomorphic.
2. Corolla papilionaceous, descending imbricate.
3. Stames 10, diadelphous.
4. Ovary monocarpellary, unilocular with marginal placentation.]



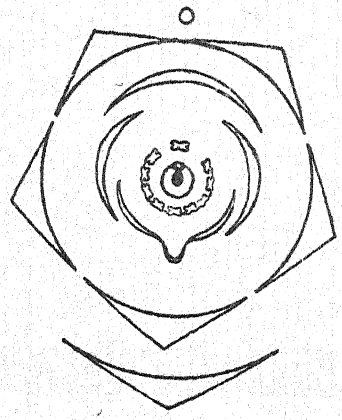
L. S. FLOWER



A FLOWERING TWIG



FRUIT



FLORAL DIAGRAM



T. S. OVARY

Fig. 209. *Pisum sativum* (Papilionata

Example 2. *Melilotus alba* (Indian Clover ; Hindi-Senji)

Habit—A wild annual herb.

Root—Branched tap root, root nodules present.

Stem—Aerial, erect, branched, solid, cylindrical, herbaceous, green.

Leaf—Cauline, compound, petiolate, stipulate, trifoliate, leaflet petiolulate, ovate, serrate, acute, unicostate reticulate.

Inflorescence—Racemose.

Flower—Pedicellate, bracteate, complete, bisexual, irregular, zygomorphic, pentamerous, cyclic, perigynous, yellow.

Flower—Pedicellate, bracteate, complete, bisexual, irregular, zygomorphic, pentamerous, cyclic, perigynous, yellow.

Calyx—Sepals 5, gamosepalous, odd sepal anterior, valvate, bell shaped.

Corolla—Petals 5, polypetalous, papilionaceous, descending imbricate, yellow.

Androecium—Stamens 10, (9) +1, diadelphous, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, ovary half-inferior, style 1, curved, stigma 1, simple.

Fruit—Legume

Floral Formula

Br, %, ♂♀, K (5), C 5 or 1+2+ (2), A (9)+1, G1-.

Systematic Position

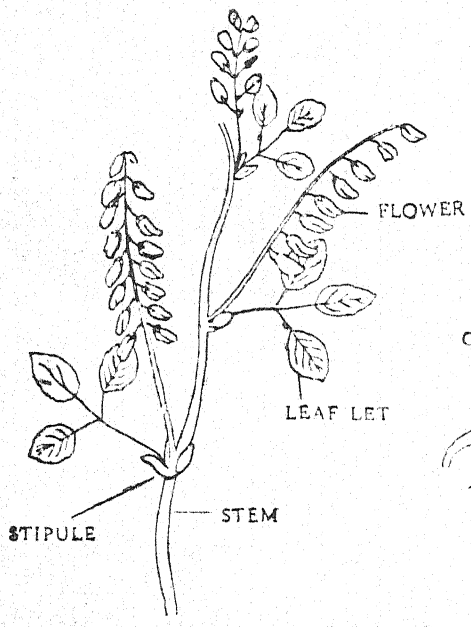
Class—Dicotyledons

Sub-Class—Polypetalae

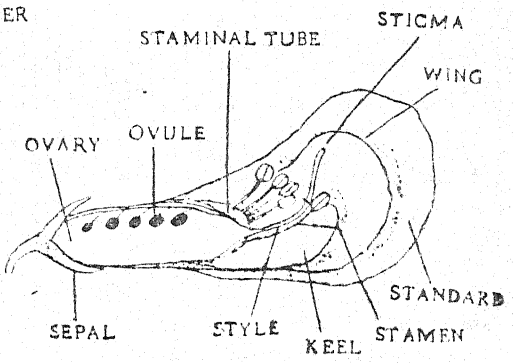
Series—Calyciflorae

Order—Rosales

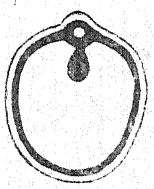
Family—Fabaceae



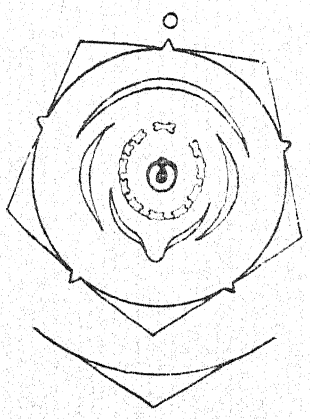
A FLOWERING TWIG



L. S. FLOWER



T. S. OVARY



FLORAL DIAGRAM

Fig. 210. *Melilotus indica* (Papilionata e)

Example 3. *Clitoria ternatea* (Hindi-Aparajit)

Habit—A wild or cultivated annual or perennial climber.

Root—Branched tap root.

Stem—Aerial, erect, branched, climber, cylindrical, slender, green.

Leaf—Petiolate, compound, stipulate, stipules linear, leaf, imparipinnate, leaflets 5 to 7, sessile, ovate, entire, obtuse, unicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, zygomorphic, perigynous, blue.

Calyx—Sepals 5, polysepalous but slightly fused at base, imbricate.

Corolla—Petals 5, polypetalous, papilionaceous, descending imbricate blue.

Androecium—Stamens 10, diadelphous, (9) + 1, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, ovary half-inferior, ovary elongated and curved, style 1, short, stigma flattened.

Fruit—Pod.

Floral Formula

Br, %, ♂, K5, C 1+2+(2), A (9)+1, G1—.

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Calyciflorae

Order—Rosoles

Family—Fabaceae

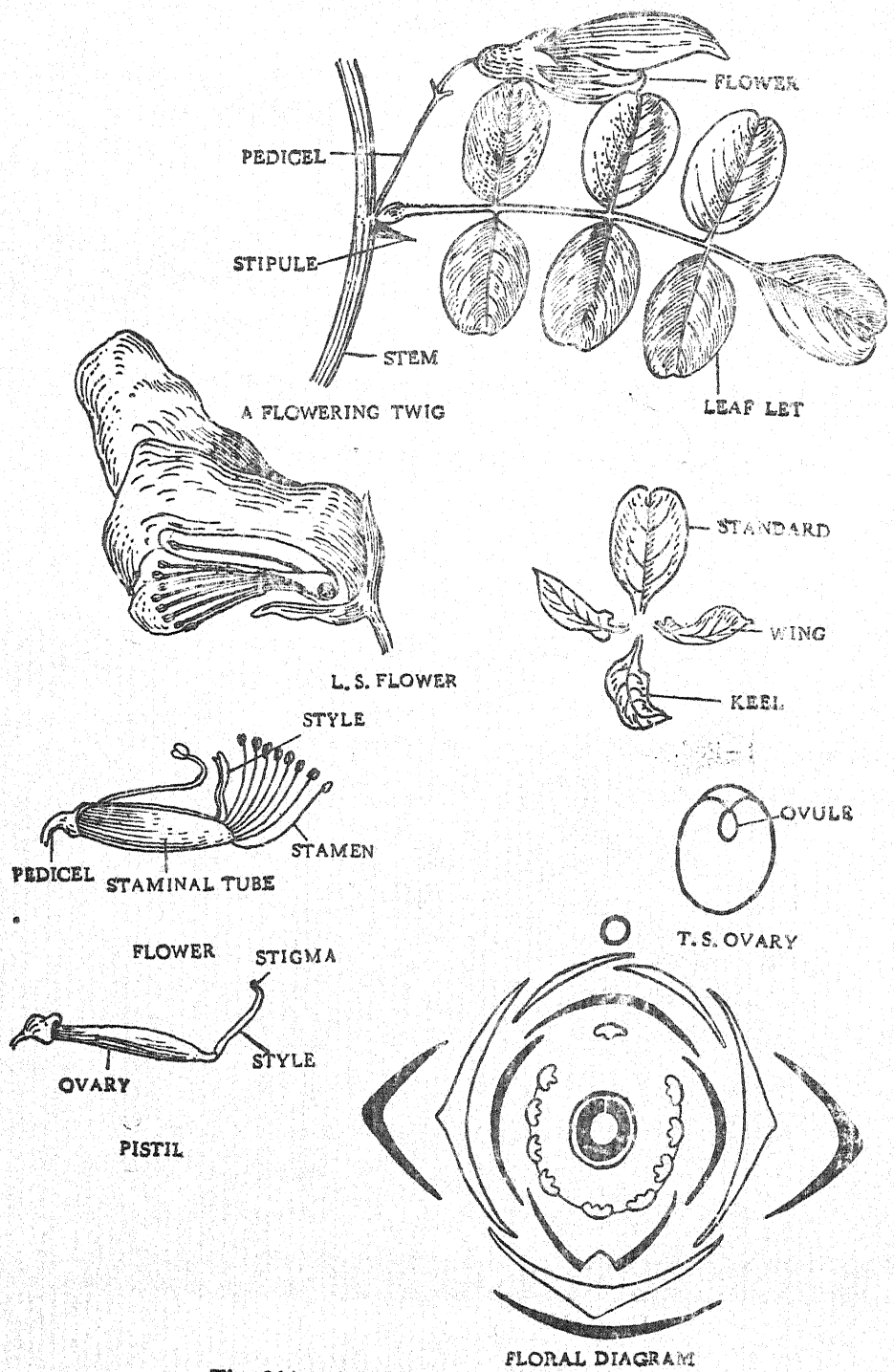


Fig. 211. ***Clitoria ternatea*** **(Papilionatae)**

Example 4. *Indigofera enneaphylla* (Hindi-Bhunguli)

Habit—A wild annual herb.

Root—Tap root.

Stem—Prostrate, aerial, branched, herbaceous, cylindrical, hairy, green.

Leaf—Compound, cauline, petiolate, petiole short, stipulate, leaflets 7-11, imparipinnate, leaflet sessile, small, ovate, entire, obtuse, unicostate reticulate.

Inflorescence—Axillary racemose.

Flower—Pedicellate, bracteate, complete, bisexual, zygomorphic, perigynous, bright red or pink, cyclic.

Calyx—Sepals 5, gamosepalous, odd sepal anterior, valvate.

Corolla—Petals 5, polypetalous, papilionaceous, descending imbricate, red or pink.

Androcium—Stamens 10, diadelphous, (9) +1, filament short, anther dithecous, dorsifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, half-inferior ovary, style short, 1, stigma flattened.

Fruit—Legume

Floral Formula

Br, %, $\overset{\circ}{\underset{}{\male}}$ +, K (5), C 1+2+(2), A (9)+1, G1—.

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Calyciflorae

Order—Rosales

Family—Fabaceae

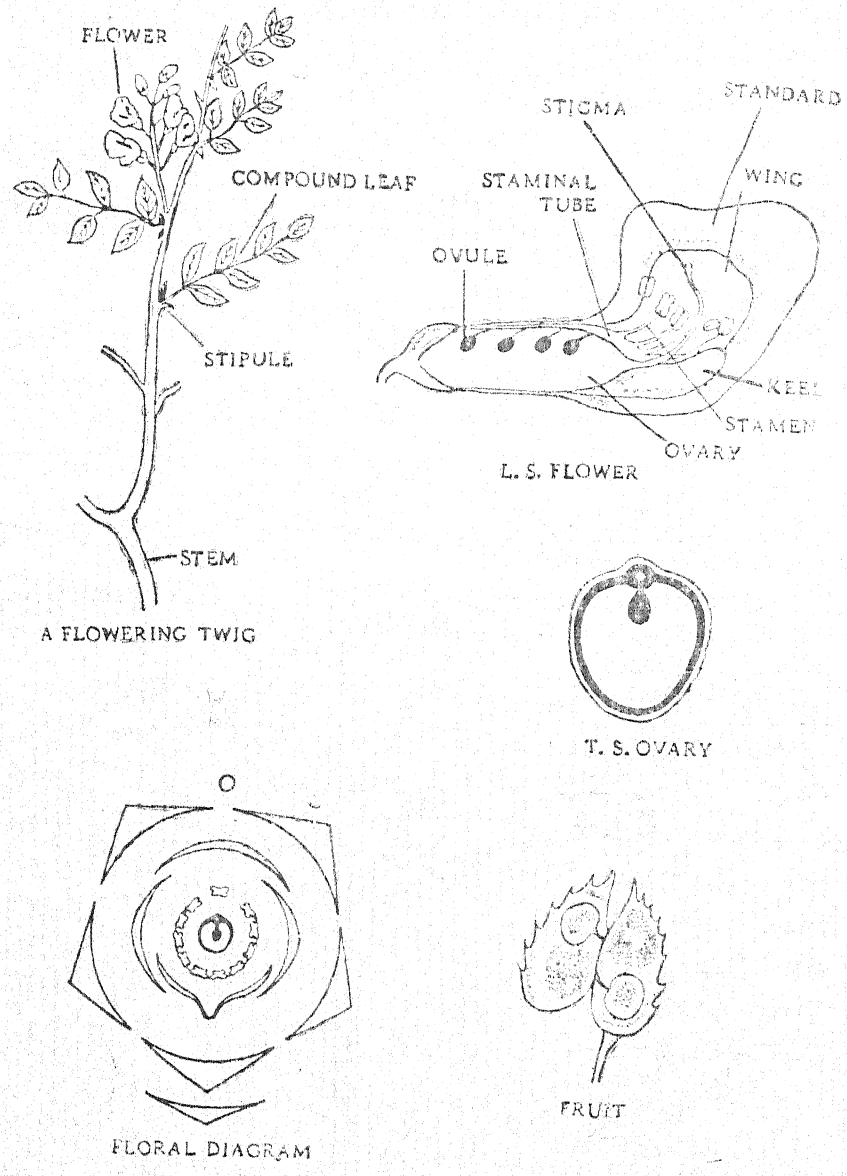


Fig. 212. ***Indigofera enneaphylla*** **(Papilionatae)**

CAESAL PINIACEAE OR CASSIACEAE (CAESALPINIOIDEAE)

Example 1. *Cassia fistula* (Hindi-Amaltas)

Habit—A perennial cultivated tree.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid.

Leaf—Petiolate, compound, alternate, stipulate, paripinnate, leafbase pulvinus, leaflets 3—8 pairs, large, subsessile, pulvinus present, opposite, ovate, entire, acute, glabrous, gland present in between the lowest pair of leaf lets, unicostate reticulate.

Inflorescence—Axillary racemose.

Flower—Pedicellate, bracteate, complete, bisexual, irregular, zygmorphic, pentamerous, cyclic, slightly perigynous, yellow.

Calyx—Sepals 5, polysepalous, odd sepal anterior, imbricate.

Corolla—Petals 5, polypetalous, clawed, alternating to sepals, ascending imbricate, odd petal posterior.

Androecium—Stamens 10, unequal, polyandrous, in 2 whorls of 5 each, 3 posterior stamens ill developed *i. e.*, staminodes, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, ovary sickle shaped, lower portion sterile), superior, style short, stigma hairy, capitate.

Fruit—Legume or pod.

Floral Formula

Br, %, $\overset{\delta}{\underset{+}{\circ}}$, K_5, C_5, A5+ 5,3 staminodes, G_1—.

Systematic Position

Class—Dicotyledons

Sub-Class—Potypetalae

Series—Calyciflorae

Order—Rosales

Family—Cassiaceae

[1. Flowers zygomorphic.

2. Descending imbricate corolla.

3. Gynoceium monocarpellary, unilocular with marginal placentation, ovary semi-inferior.]

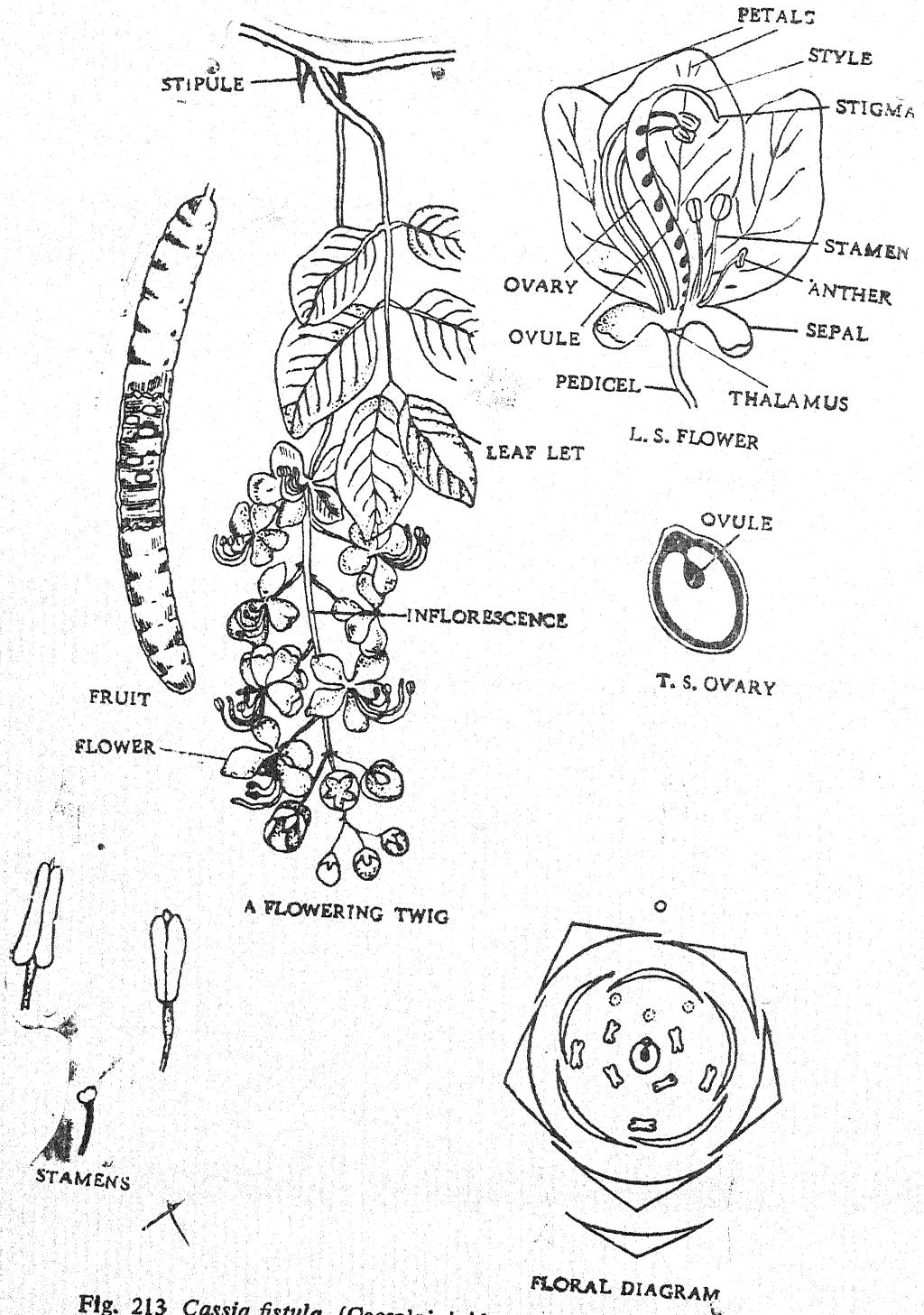


Fig. 213 *Cassia fistula* (Caesalpinioideae or Cassiaceae)

Example 2.—*Bauhinia variegata* Syn. *B. candida* (Hindi-Kachnar)

Habit—A cultivated perennial tree.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid, green.

Leaf—Petiolate, simple, alternate, stipulate, bilobed, apically entire, multicostate reticulate.

Inflorescence—Axillary racemose.

Flower—Pedicellate, bracteate, complete, bisexual, irregular, zygomorphic, showy, slightly perigynous, pentamerons, cyclic, white or pink.

Calyx—Sepats 5, polysepalous, shightly fused at base, odd sepal anterior, imbricate.

Corolla—Petals 5, polypetalous, alternating to sepals, odd petal posterior, ascending imbricate, white or pink.

Androecium—Stamens 5, polyandrous, alternating to petals, filament long, anther dithecous, versatile, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, ovary superior, curved, present on a stalk, style short, stigma simple and sticky.

Fruit—Legume.

Floral Formula

Br, %, $\underset{\varphi}{\sigma}$, K_5, C_5, A_5, $\underline{G_1}$.

Systematic Position

Class—Dicotyledons

Sub-class—Polypetalae

Series—Calyciflorae

Order—Rosalas

Family—Cassiaceae

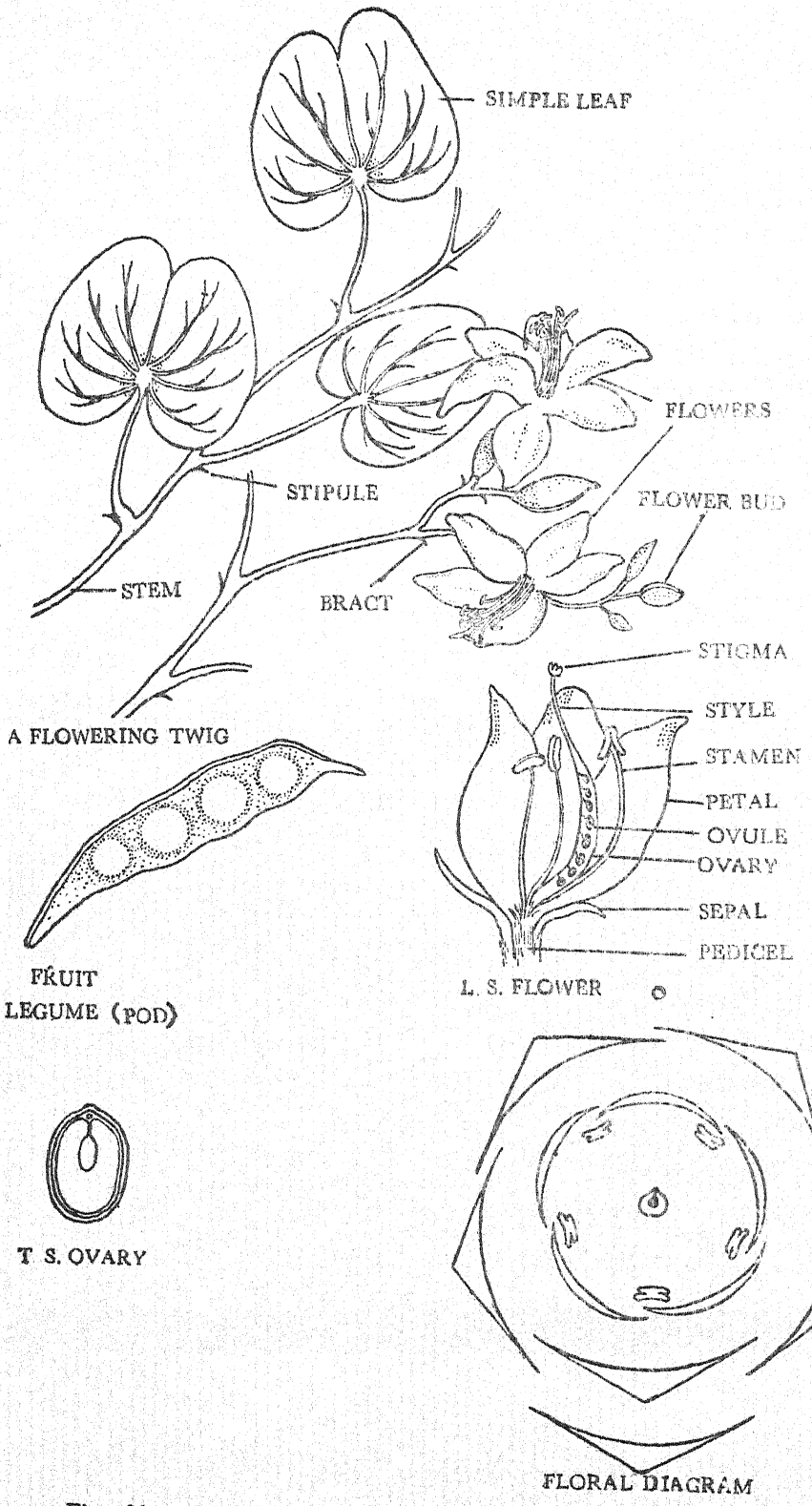


Fig. 214. *Bauhinia variegata* (Caesalpinioideae or Cassiaceae)

MIMOSACEAE (MIMOSOIDEAE)

Example 1. *Mimosa pudica* (Touch-me-not ; Hindi-Lajwanti)

Habit—A wild or cultivated perennial undershrub.

Root—Branched tap root.

Stem—Aerial, erect or prostrate, branched, cylindrical, woody, solid, green or brownish green, prickly.

Leaf—Compound, bipinnate, cauline, alternate petiolate, stipulate, stipules bristle-like, leaf base pulvinus, leaflets small, sessile, oblong, entire, acute, unicostate reticulate, digitate, sensetive to touch or stimulus, caducous.

Inflorescence—Axillary racemose heads, usually in pairs.

Flower—Sessile, bracteate, complete, bisexual, regular, actinomorphic, tetramerous, small, perigynous, yellow.

Calyx—Sepals 4, gamosepalous, valvate.

Corolla—Petals 4, polypetalous, alternating to sepals, tubular, valvate, yellow.

Androecium—Stamens 4, polyandrous, alternating to petals, filament long, filiform, anther dithecous, dorsifixed, introrse.

Gynoecium—Monocarpellary, unilocular, marginal placentation, superior ovary, style long, stigma linear, simple.

Fruit—Lomentum

Floral Formula

$$Br,\ \oplus,\ \mathrm{\overset{+}{\sigma}},\ K(4),\ C4,\ A_4,\ \underline{G_1}.$$

Systematic Position

Class—Dicotyledons

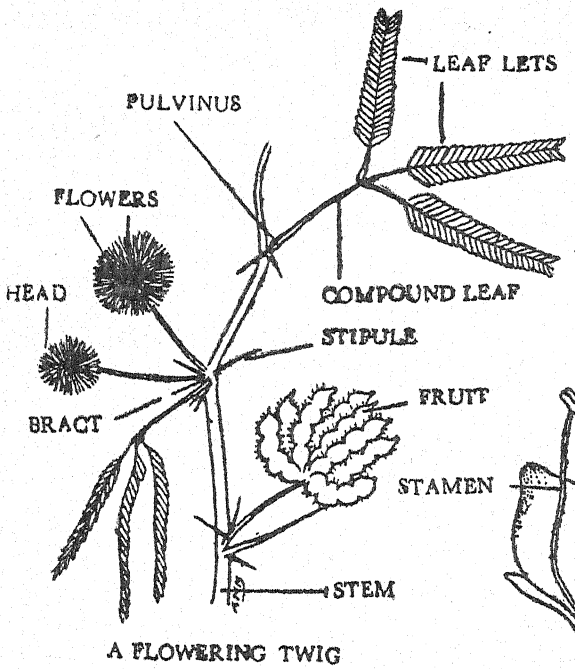
Sub-Class—Polypetalae

Series—Calyciflorae

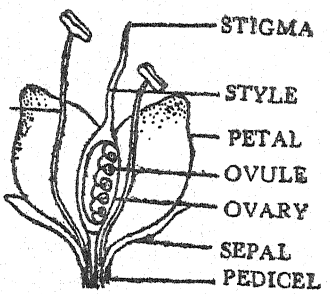
Order—Rosales

Family—Mimosaceae

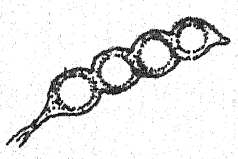
[1. Flowers actinomorphic. 2. Corolla valvate, 3. Ovary monocarpellary and superior. 4. Fruit usually lomentum.]



A FLOWERING TWIG



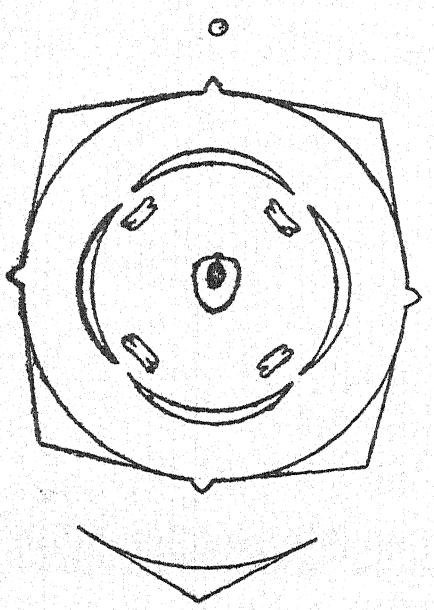
L. S. FLOWER



FRUIT
(LOMENTUM)



T. S. OVARY



FLORAL DIAGRAM

Fig. 214. *Mimosa pudica* (Mimosoideae or Mimosaceae)

ROSACEAE

Example 1. *Potentilla supina*

Habit—A wild annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, hairy, green.

Leaf—Cauline, compound, imparipinnate, petiolate, stipulate, stipules adnate to petiole, opposite, leaflets usually 3—9, sessile, obovate to lanceolate, serrate, obtuse to acute, unicostate reticulate, hairy.

Inflorescence—Solilary axillary.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, pentamerous, hypogynous, spirocyclic, yellow.

Epicalyx—5, joined (connate) with sepals.

Calyx—Sepals 5, polysepalous, joined (connate) with epicalyx, odd sepal posterior, valvate, alternating to epicalyx members.

Corolla—Petals 5, polypetalous, alternating to sepals, valvate, yellow.

Androecium—Stamens indefinite, polyandrous, flament slender, anther dithecous, basifixed, introrse.

Gynoecium—Multicarpellary, apocarpous, each unilocular, basal placentation, single basal ovule, superior ovary, style short, persistent, lateral, stigma minute and pointed.

Fruit—Etario of achenes.

Floral Formula

$$\text{Br}, \oplus, \underset{\varphi}{\overset{\sigma}{}}, \widehat{\text{Epi}_5}, \widehat{\text{K}_5}, \text{C}_5, \text{A}\infty, \underline{\text{G}\infty}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Calyciflorae

Order—Rosales

Family—Rosaceae

[1. Corolla 5, rosaceous.

2. Stamens indefinite, free and bent in bud condition.

3. Ovary free or united, inferior or superior.

4. Flowers regular and bisexual.

5. Leaves stipulate.]

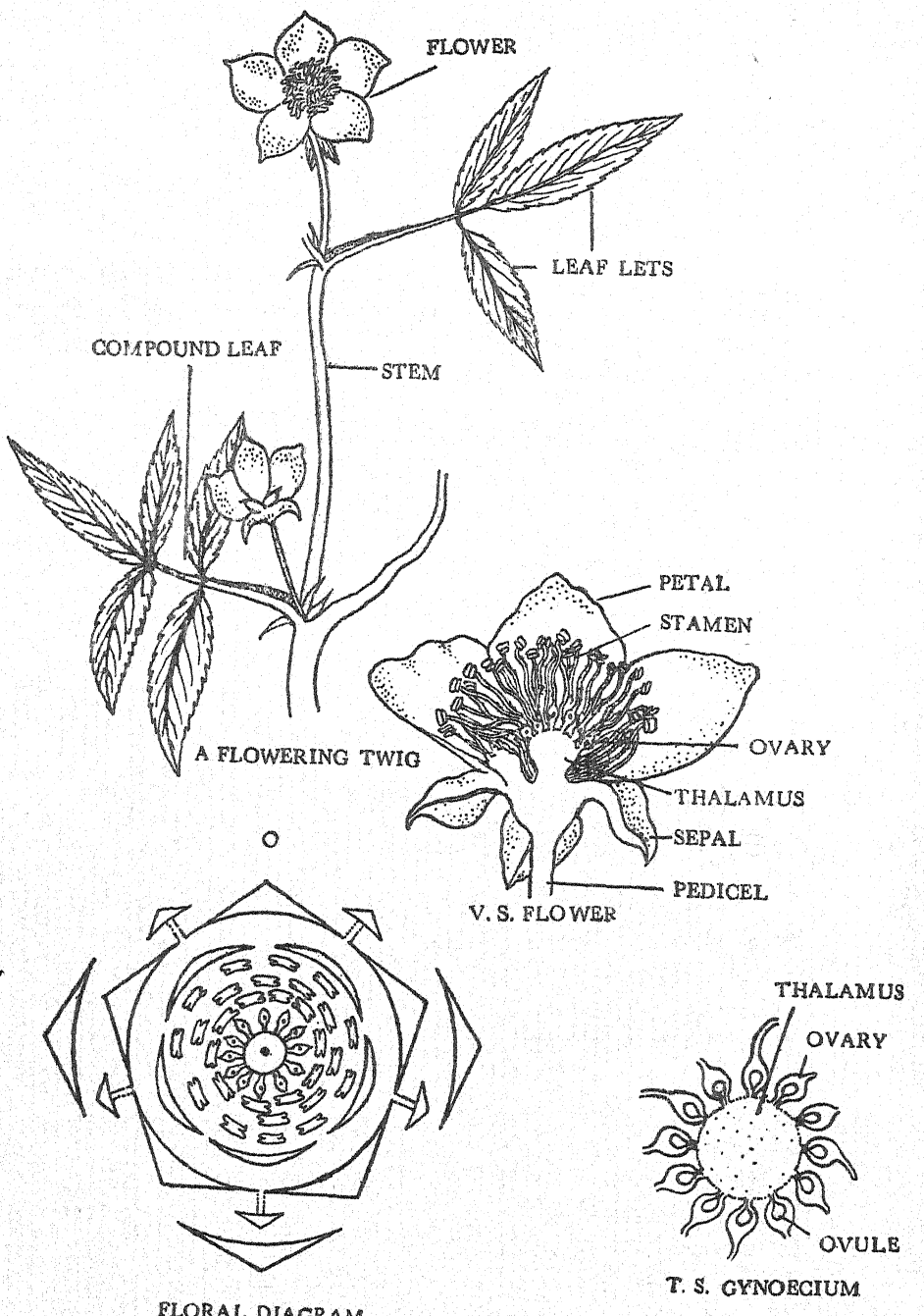


Fig. 216. *Potentilla supina* (Rosaceae)

MYRTACEAE

Example 1. *Callistemon lanceolatus* Syn. *C. citrinus* (Bottle brush)

Habit—A cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, angular, dark brown, glabrous or hairy, sometimes spiny, upper part herbaceous, cylindrical.

Leaf—Cauline, sub-sessile, simple, alternate, exstipulate, lanceolate, entire, acute, unicostate reticulate, leathery, dotted oil glands present, with aromatic smell.

Inflorescence—Intercalary spike.

Flower—Sub-sessile, bracteate, complete, bisexual, regular, actinomorphic, pentamerous, epigynous, cyclic, red.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, polypetalous, alternating to sepals, imbricate, red.

Androecium—Stamens indefinite, polyandrous, filament bright red, unite to form a staminal sheath, anther small, dark brown, dithecous, dorsifixed, introrse.

Gynoecium—Tricarpellary, syncarpous, trilocular, axile placentation, many ovules in each locule, ovary inferior, style long, stigma capitate.

Fruit—Capsule

Floral Formula

Class—Dicotyledons

Sub-class—Polypetalae

Series—Calyciflorae

Order—Myrtales

[1. Leaf simple, entire. 2. ovary syncarpous and inferior with axile placentation.]

Family—Myrtaceae

[1. Leaves alternate or opposite, exstipulate. 2. Stamens indefinite, polyandrous, some times filaments unite at base. 3. Ovary multicarpellary i.e. 2—8.]

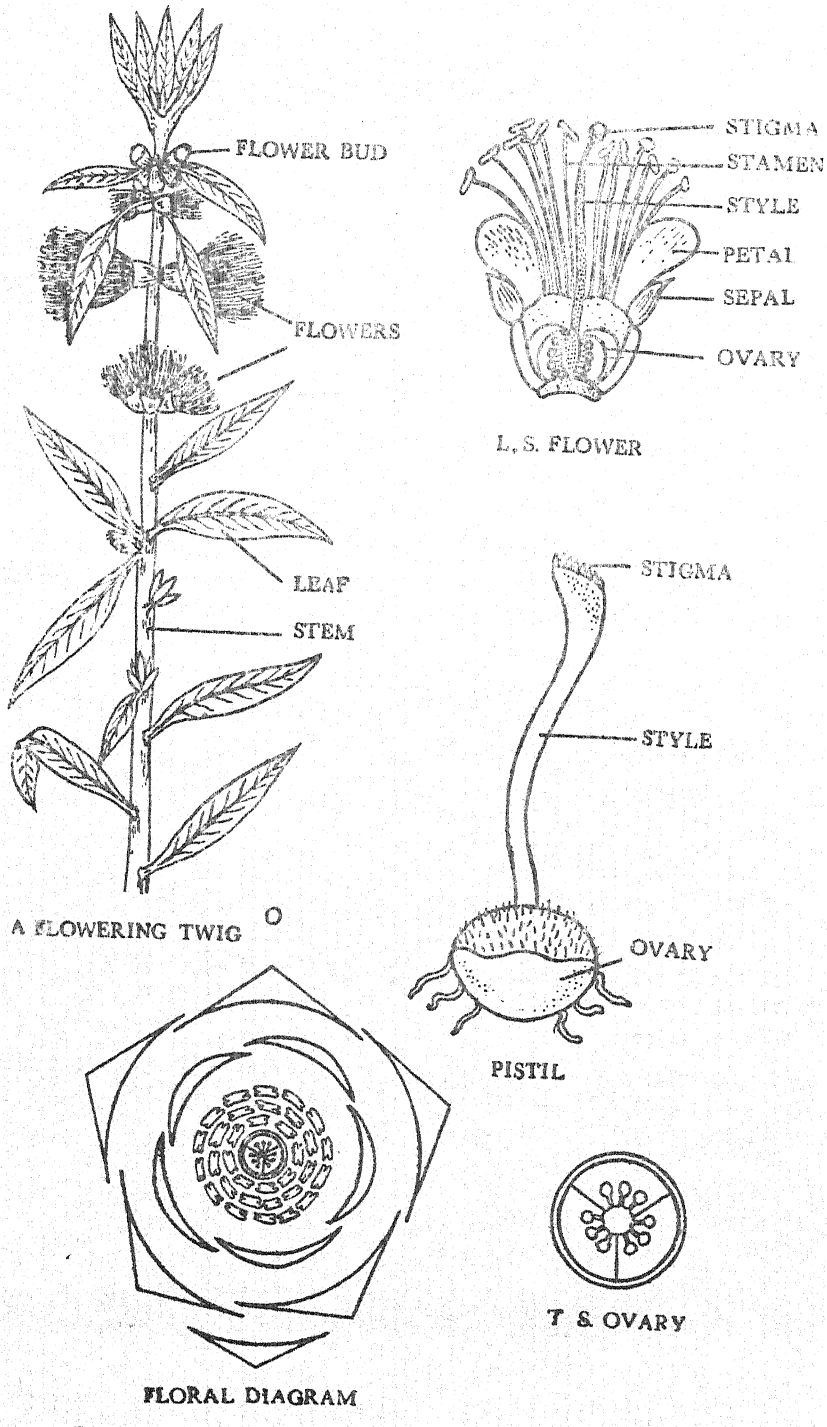


Fig. 217. *Callistemon lanceolatus* (Myrtaceae)

CUCURBITACEAE

Example 1. *Coccinia cordifolia Syn. C. indica* (Hindi-Kanduri)

Habit—A wild perennial climbing herb.

Root—Branched tuberous tap root.

Stem—Aerial, weak, herbaceous, climbing, branched, angular, solid, tendrillar, tendril simple, unbranched, stem green and hairy.

Leaf—Petiolate, simple, cauline, exstipulate, alternate, glaucous, cordate, lobed, multicostate reticulate.

Inflorescence—Solitary axillary.

Flower—Pedicellate, ebracteate, incomplete, unisexual, actinomorphic, cyclic, pentamerous, epigynous in case of female flower, white.

Male Flower

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, gamopetalous, alternating to sepals, valvate, white.

Androecium—Stamens 5, arranged in 3 groups, 2 groups have 2 stamens each and the third group has only one stamen (known as double stamen and single stamen), synandrous, extrorse, anther spirally coiled.

Gynoecium—Absent.

Floral Formula

Ebr, ⊕, ♂, $K_{(5)}$, $C_{(5)}$, $A_{(3)}$, Go.

Female Flower

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, gamopetalous, alternating to sepals, valvate, white.

Androecium—Absent.

Gynoecium—Tricarpellary, syncarpous, unilocular, (or 3 trilocular), parietal placentation, placenta intruding, ovules many, ovary inferior, style short, stigma 3, forked, feathery.

Fruit—Pepo.

Floral Formula : Ebr, ⊕, ♀, $K_{(5)}$, $C_{(5)}$, Ao, $\underline{G(\overline{3})}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae (though in this plant petals are united)

Series—Calyciflorae

Order—Passiflorales

[1. Tendril present, climber.

2. Ovary syncarpous, unilocular, parietal placentation.]

Family—Cucurbitaceae

[1. Flowers unisexual 2. Usually stamens 5, in 3 groups or all 5 in a central synandrium. 3. Carpels 3, syncarpous, stigma forked. 4. Fruit pepo.]

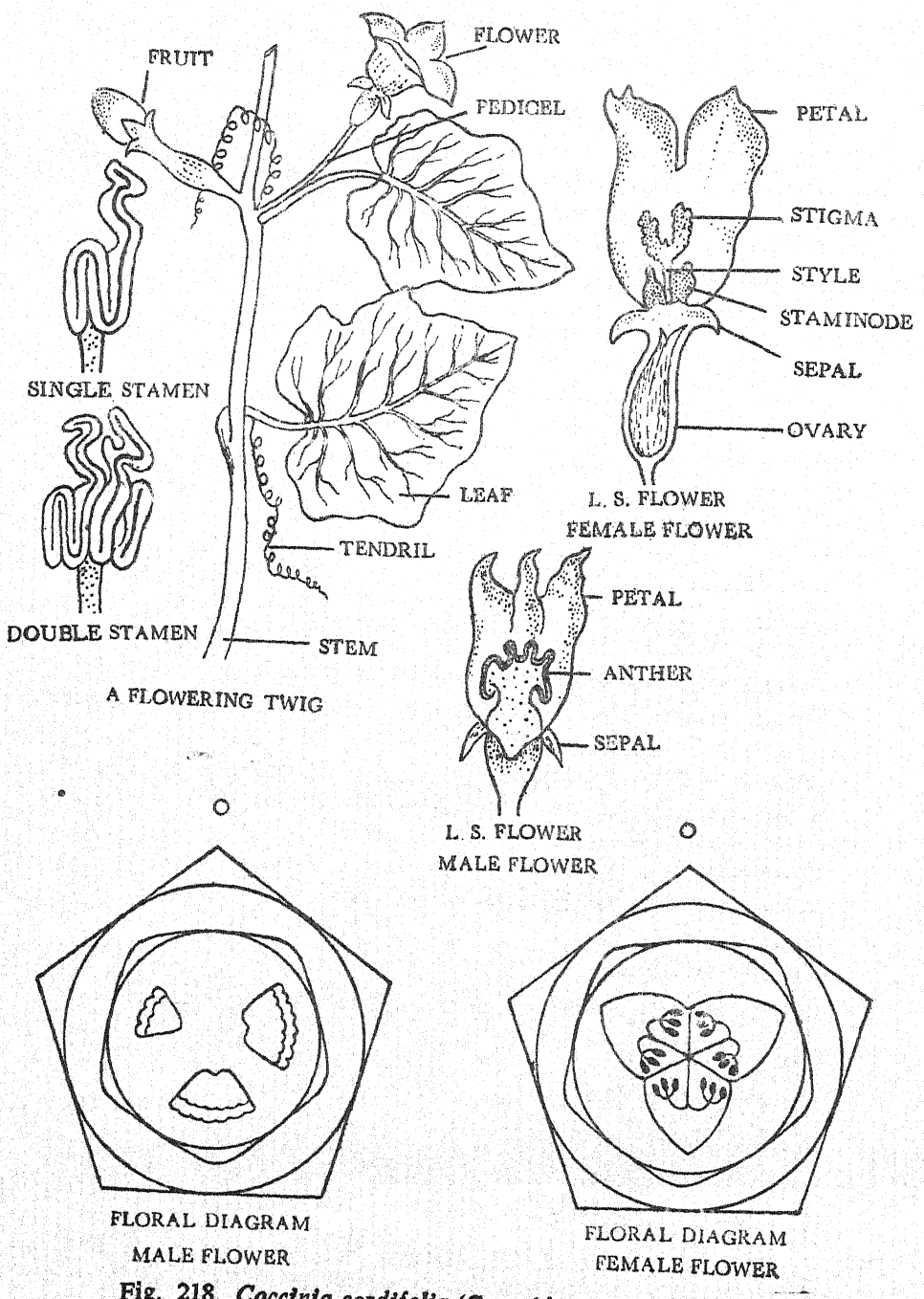


Fig. 218. ***Coccinia cordifolia*** **(Cucurbitaceae)**

UMBELLIFERAE (APIACEAE)

Example 1. *Coriandrum sativum* (Coriander; Hindi-Dhaniya)

Habit—An annual cultivated herb.

Root—Branched tap root.

Stem—Aerial, erect, herbaceous, angular to cylindrical, glabrous, branched, solid, nodes prominent (swollen).

Leaf—Cauline and ramal, petiolate, exstipulate, alternate, compound, decompound, leafbase sheathing, upper leaves highly dissected, pinnae entire, needle like, acute, unicostate reticulate, with aromatic smell.

Inflorescence—Compound umbel.

Flower—Pedicellate, bracteate, complete, bisexual, central flowers actinomorphic, peripheral flowers zygomorphic, pentamerous, cyclic, epigynous, pink.

Calyx—Sepals 5, gemosepalous, odd sepal posterior, upper part free, valvate.

Corolla—Petals 5, polypetalous, alternating to sepals valvate, each petal bilobed.

In actinomorphic flowers the two lobes of a petal are equal but in zygomorphic flowers anterior petal has equal lobes, two lateral petals have unequal lobes and the rest two petals have equal lobes.

Androecium—Stamens 5, polyandrous, alternating to petals, filament long, slender, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, one pendulous ovule in each locule, placentation axile, style 2, stigma 2, capitate, stylopodium present below the style.

Fruit—Cremocarp, splits up into 2 mericarps.

Floral Formula

Actinomorphic Flower (Central Flower)

$$Br,\ +,\ \varphi^{\delta},\ K_5,\ C_5,\ A_5,\ \underline{G(\overline{2})}.$$

Zygomorphic Flower (Peripheral Flower)

$$Br,\ \%,\ \varphi^{\delta},\ K_5,\ C_5,\ A_5,\ \underline{G(\overline{2})}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Polypetalae

Series—Calyciflorae

Order—Umbellales

[1. Umbel inflorescence. 2. Ovary bicarpellary or carpel 1, 2 or 8, syncarpons, inferior ovary. 3. Ovule single in each locule, pendulous].

Family—Umbelliferae

[1. Stems fistular. 2. Leaf alternate, exstipulate, dissected, sheathing at base. 3: Carpels usually 2, fused, style 2, on stylopodium. 4. Fruit schizocarpic, mericarps 2.].

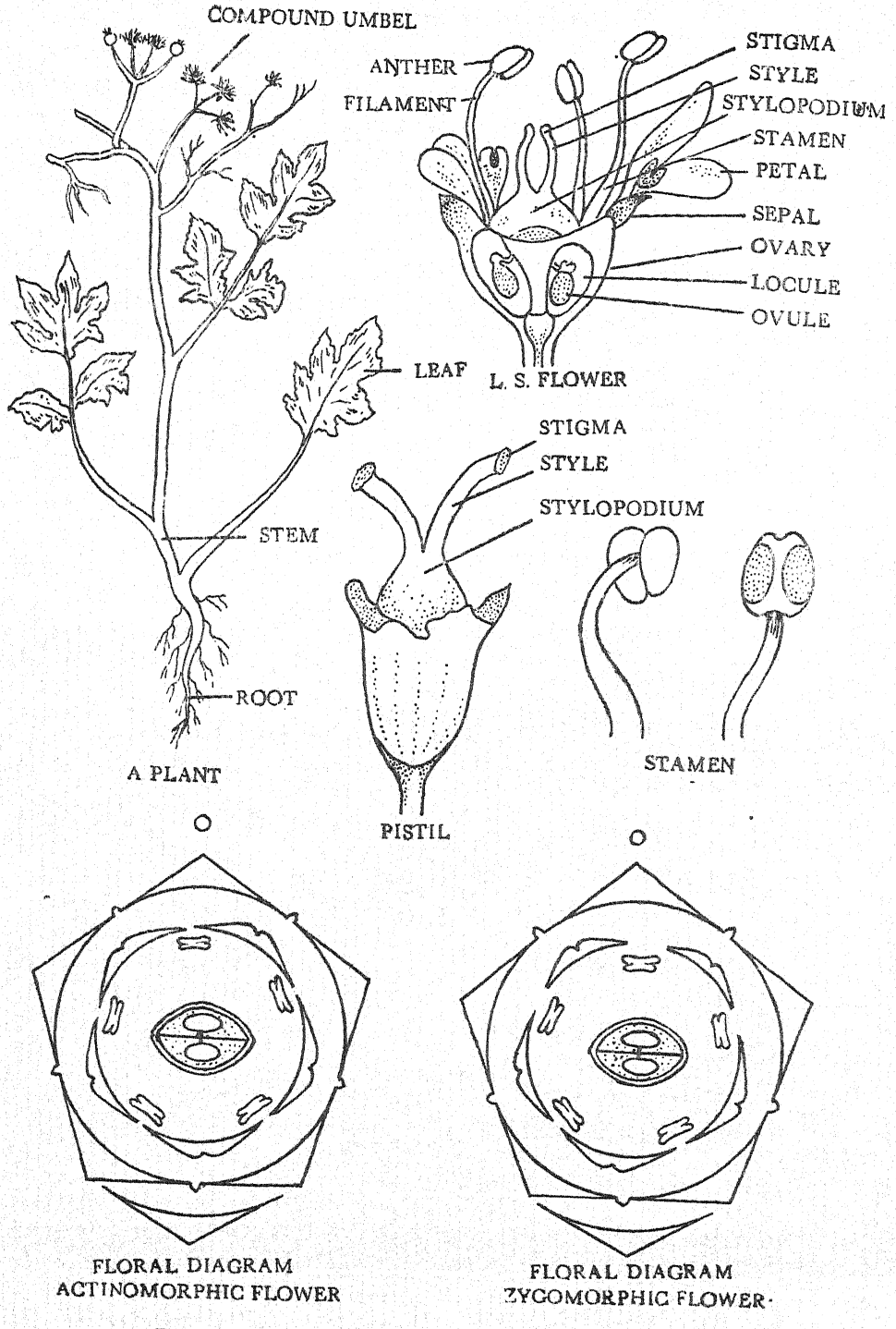


Fig. 219. *Coriandrum sativum* (Umbelliferae)

Example 2. *Foeniculum vulgare* (Fennel ; Hindi-Saunf)

Habit—An annual cultivated herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, ribbed, herbaceous, fistular. glabrous, nodes prominent (swollen).

Leaf—cauline and ramal, petiolate, leaf base sheathing, exstipulate, alternate, compound, pinnate, segments linear, filiform, unicostate reticulate, with aromatic smell.

Inflorescence—Compound umbel.

Flower—Pedicellate, bracteate, complete, bisexual, actinormorphic, pentamerous, cyclic, epigynous, yellow.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate, petaloid.

Corolla—Petals 5, polypetalous, valvate, alternating to sepals, each bilobed (clawed), incurved, yellow.

Androecium—Stamens 5, polyandrous, alternating to petals, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation. ovule on each placentum, inferior ovary, style short, fused at base forming stylopodium, stigma bilobed.

Fruit—Cremocarp.

Floral Formula

$$\text{Br},\ \oplus,\ \mathrm{\mathbb{Q}}^{\mathrm{\mathbb{Q}}},\ K_{(5)}\ C_{5},\ A_{5},\ \underline{G(\overline{2})}.$$

Systematic Position

Class—Dicotyledons
Sub-class—Polypetalae
Series—Calyciflorae
Order—Umbellales
Family—Umbelliferae (Apiaceae)

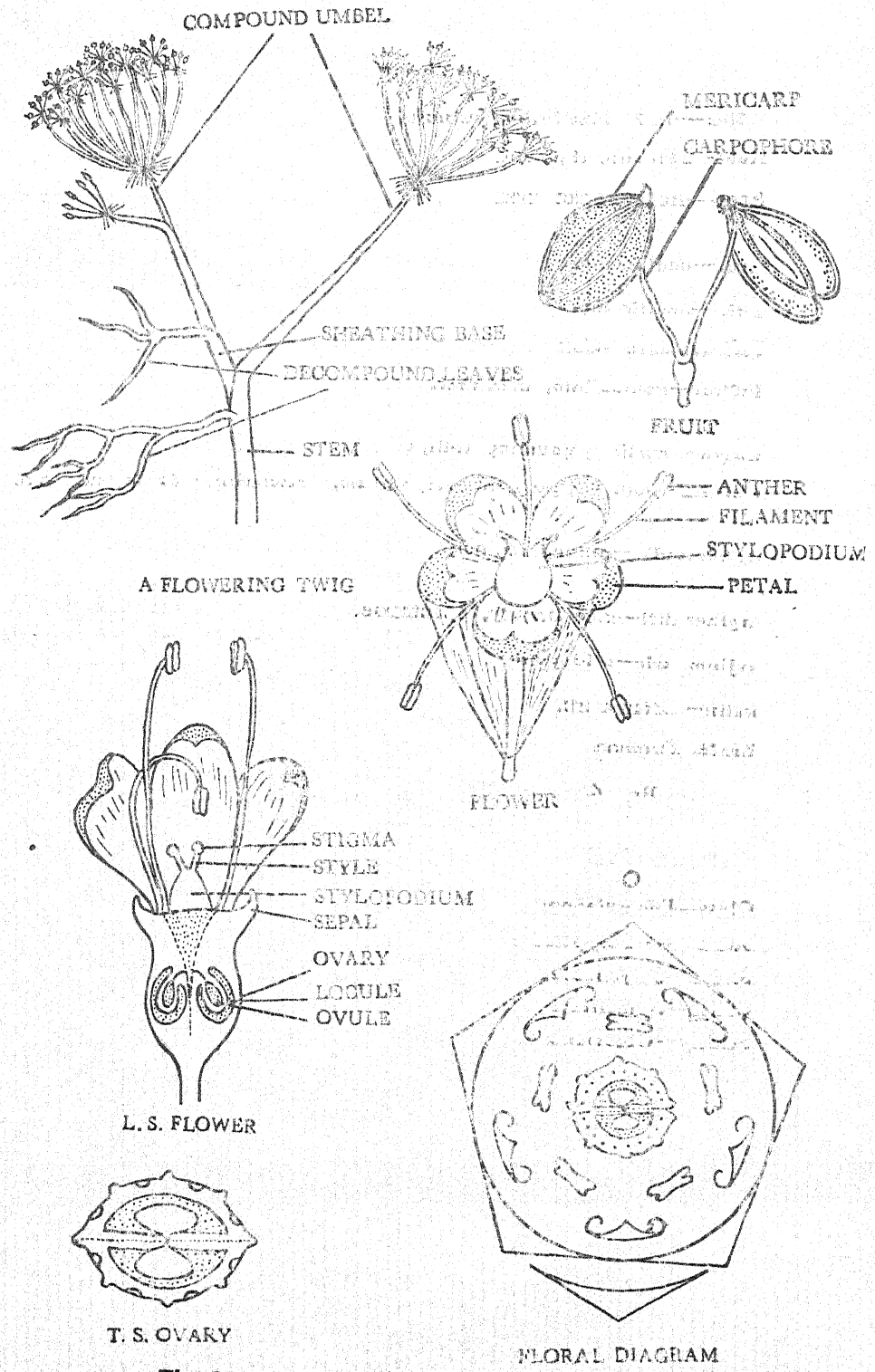


Fig. 220. *Foeniculum vulgare* (Umbelliferae).

RUBIACEAE

Example 1. *Hamelia patens*

Habit—A cultivated perennial shrub to under tree.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid, hairy, redish brown above.

Leaf—Cauline, petiolate, whorled, simple, stiputate, stipules interpetiolar, leaf ovate, entire, acute, unicostate reticulate.

Inflorescence—Multichasial cyme, dichasial cyme terminating into monochasial (helicoid cyme).

Flower—Pedicellate, ebracteate, complete, bisexual, regular, actinomorphic, pentamerous, epigynous, red.

Calyx—Sepals 5, gamosepalous, tubular, odd sepal posterior, valvate.

Corolla—Petals 5, gamopetalous, alternate to sepals, tubular, red, valvate.

Androecium—Stamens 5, polyandrous, epipetalous, alternating with petals, filament short, anther dithecous, basifixed, introrse.

Gynoecium—Pentacarpellary, syncarpous, pentalocular, axile placentation, many ovules on each placentum in each locule, style 1, filiform, stigma bifid.

Fruit—Berry.

Floral Formula

$$\text{Ebr}, \quad \oplus, \quad \mathrm{\overset{\mathrm{\mathbb{Q}}}{\mathrm{\mathbb{Z}}}}, \quad K(5), \quad C(5), \quad \overset{\frown}{A_5}, \quad \underline{G}(5).$$

Systematic Position

Class—Dicotyledons

Sub-class—Gamopetalae (petals united)

Series—Inferae

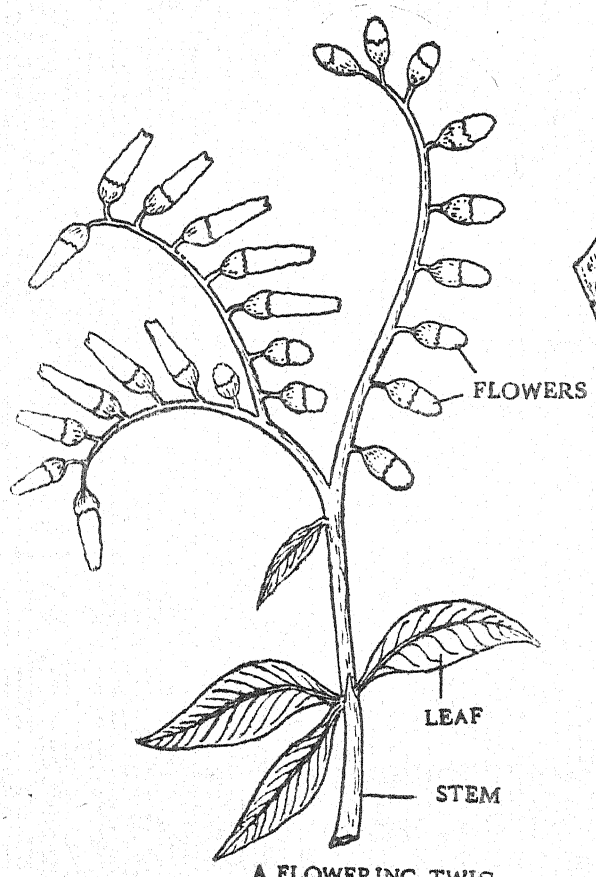
[1. Ovary inferior.
2. Stamens 4 or 5 or correspond to the number of corolla lobes.]

Order—Rubiales

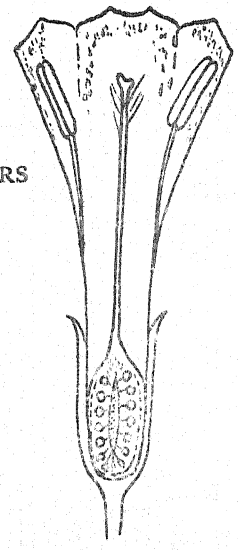
[1. Leaves opposite or whorled.
2. Stamens polyandrous and epipetalous.
3. Ovary polycarpellary, syncarpous and locules 2-8.]

Family—Rubiaceae

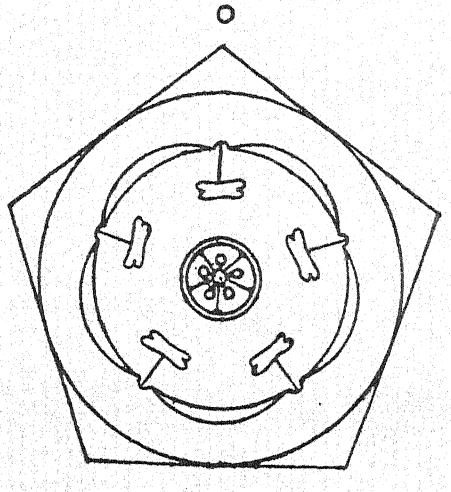
[1. Inter petiolar stipules present.
2. Inflorescence cymose.
3. Ovary bicarpellary to multicarpellary, syncarpous.
4. Epigynous ovary.
5. Placentum T-shaped.]



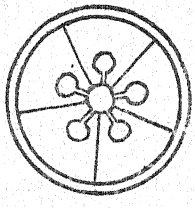
A FLOWERING TWIG



L. S. FLOWER



FLORAL DIAGRAM



T. S. OVARY

Fig. 221. ***Hamelia patens*** **(Rubiaceae)**

Example 2. *Mussaenda frondosa*

Habit—An ornamental cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, woody, solid, hairy, green.

Leaf—Cauline, opposite decussate, stipulate, stipules interpetiolar, leaf simple, sub-sessile, elliptic lanceolate, entire, acute, unicostate reticulate, hairy.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, epigynous, cyclic, pentamerous, outer flowers in the inflorescence are zygomorphic.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate. In zygomorphic flowers one of the sepals is leaf like, yellow and large.

Corolla—Petals 5, gamopetalous, alternate, valvate, tubular, hairy at mouth known as corona.

Androecium—Stamens 5, polyandrous, epipetalous, alternate, filament slender, anther dithecous, dorsifixed, protandrous, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation, many ovules in each locule, placenta T—shaped, inferior ovary, style 1, long, stigma bifid.

Fruit—Berry.

Floral Formula

Br, ⊕ or %, $K_{(5)}$, $\overbrace{C_{(5)}}$, A_5, $\underline{G(2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Inferae

Order—Rubiales

Family—Rubiaceae

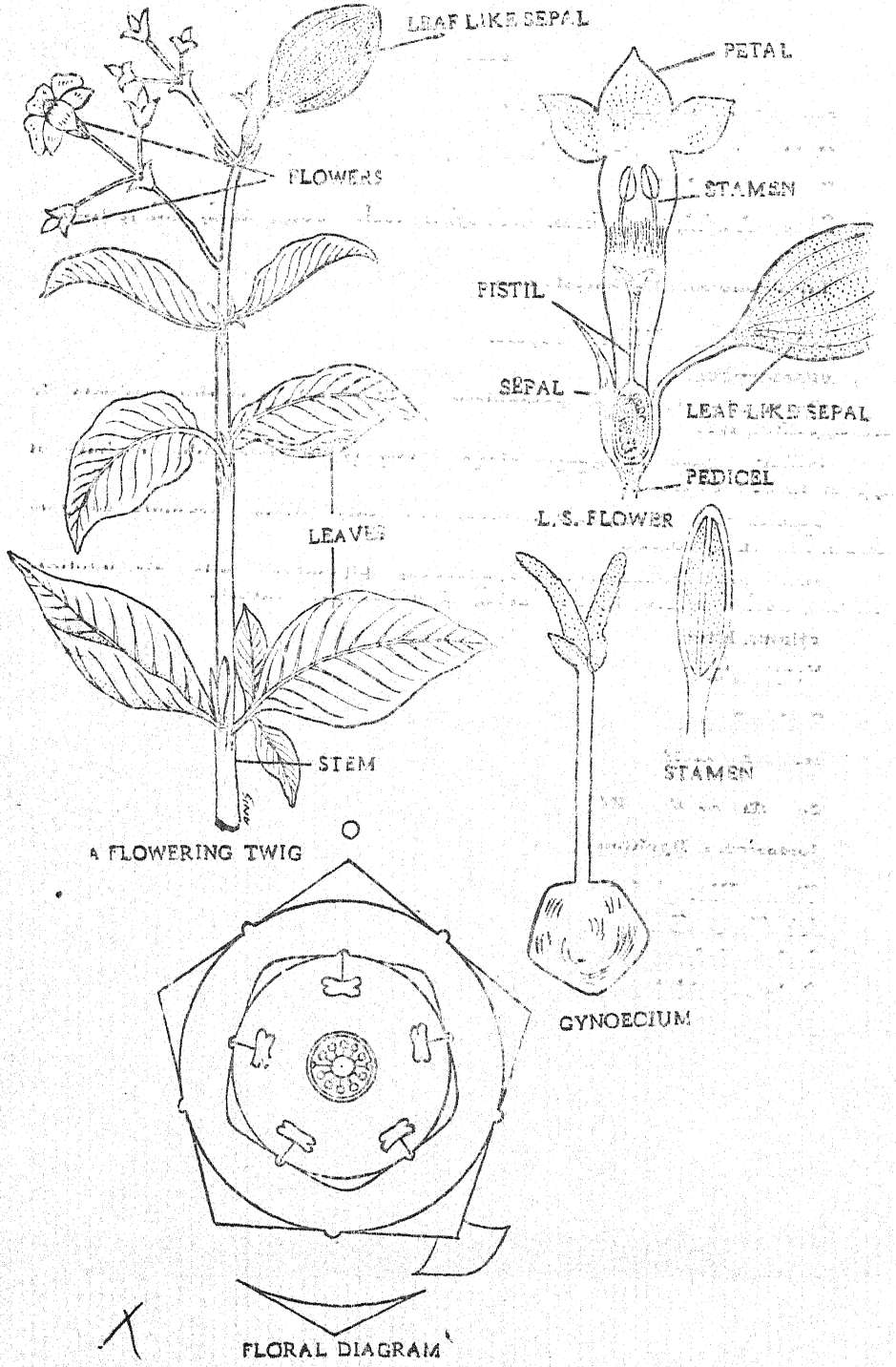


Fig. 222. ***Mussaenda frondosa*** **(Rubiaceae)**

Example 3. *Ixora arborea Syn. I. parviflora*
(Hindi-Kotagandhal)

Habit—A cultivated ornamental perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, woody, solid, cylindrical, glabrous or smooth, green.

Leaf—Cauline, opposite decussate, simple, stipulate, sessile, interpetiolor stipules present, elliptical, entire, acute, unicostate reticulate, glabrous.

Inflorescence—Corymbose cyme, terminal.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, tetramerous, cyclic, epigynous, red or white.

Calyx—Sepals 4, gamosepalous, valvate.

Corolla—Petals 4, gamopetalous, alternate, twisted, tubular red or white.

Androecium—Stamens 4, polyandrous, epipetalous, alternate, filament short, anther dithecous, dorsifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular. axile placentation, placentum T—shaped, inferior ovary, 1 ovules in each locule, style 1, long, stigma bifid.

Fruit—Berry.

Floral Formula

$$Br,\ \oplus,\ \underset{\varphi}{\overset{\sigma}{}},\ K_{(4)},\ \widehat{C_{(4)}, A_4},\ \underline{G(\overline{2})}.$$

Sysetematic Position

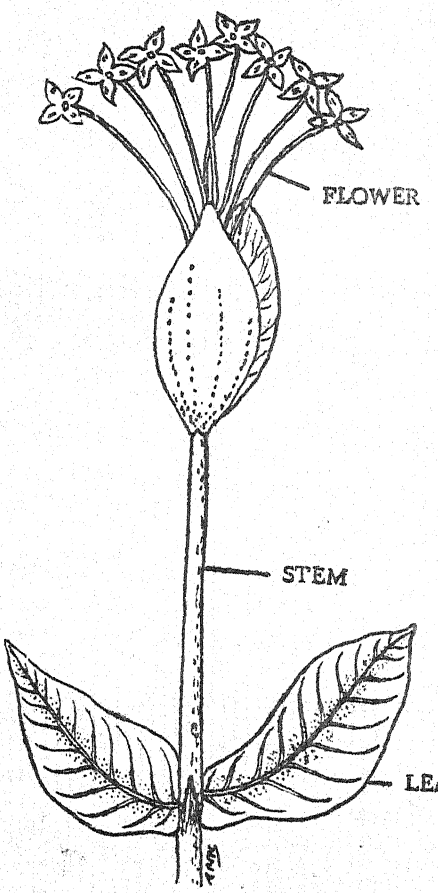
Class –Dicotyledons

Sub-Class—Gamopetalae

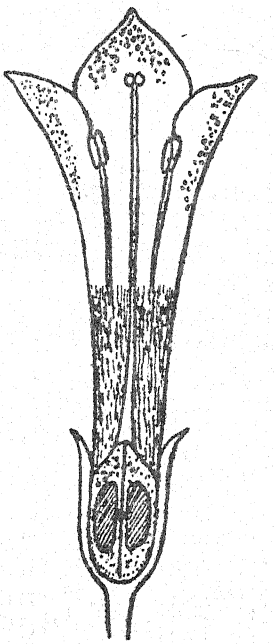
Series—Inferae

Order—Rubiales

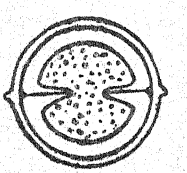
Family—Rubiaceae



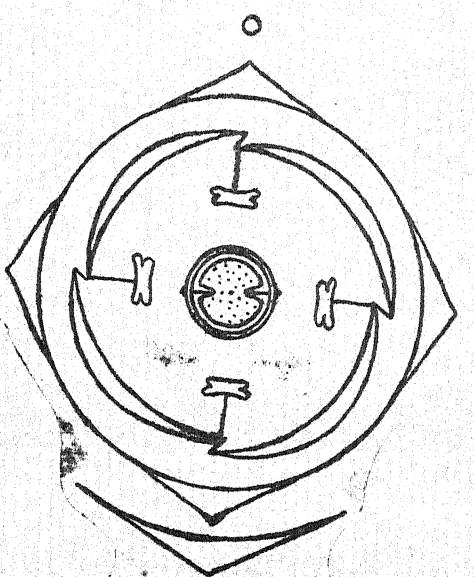
A FLOWERING TWIG



L. S. FLOWER



T. S. OVARY



FLORAL DIAGRAM

Fig. 223. *Ixora arborea* (Rubiaceae)

COMPOSITAE (ASTERACEAE)

Example 1. *Ageratum conyzoides* (Goat-weed)

Habit—An annual wild herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, solid, hairy, green to purple-green.

Leaf—Cauline, simple, petiolate, exstipulate, lower leaves opposite, upper leaves alternate, ovate, serrate, acute, unicostate reticulate, hairy.

Inflorescence—Compound capitulum, heads arranged in cymose manner, involucre of bracts present, all the flowers tubular, inflorescence homozygous.

Flower—Sessile, bracteate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, epigynous, tubular, violet.

Calyx—Sepals 5, polysepalous, reduced to long, scaly structure called pappus, valvate.

Corolla—Petals 5, gamopetalous, valvate, tubular, violet, alternate.

Androecium—Stamens 5, syngenesious, epipetalous, filament long, thread-like, anthers joined round the style, dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular, basal placentation, ovule one, ovary inferior, style long, stigma bifid and curved down ward.

Fruit—Cypsella

Floral Formula

Br, ⊕, ♂, K5 (pappus), $C\overset{\frown}{(5)}$, $\overset{\frown}{A}(5)$, $G\underline{(2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Inferae

Order—Asterales

[1. Stamens epipetalous 2. Ovary bicarpellary, syncarpous, unilocular, basal placentation with 1 ovule.]

Family—Compositae (Asteraceae)

[1. Leaves usnally alternate.
2. Inflorescence capitulum.
3. Sepals modified into pappus.
4. Stamens 5, epipetatous, syngenesious and anthers join round style.]

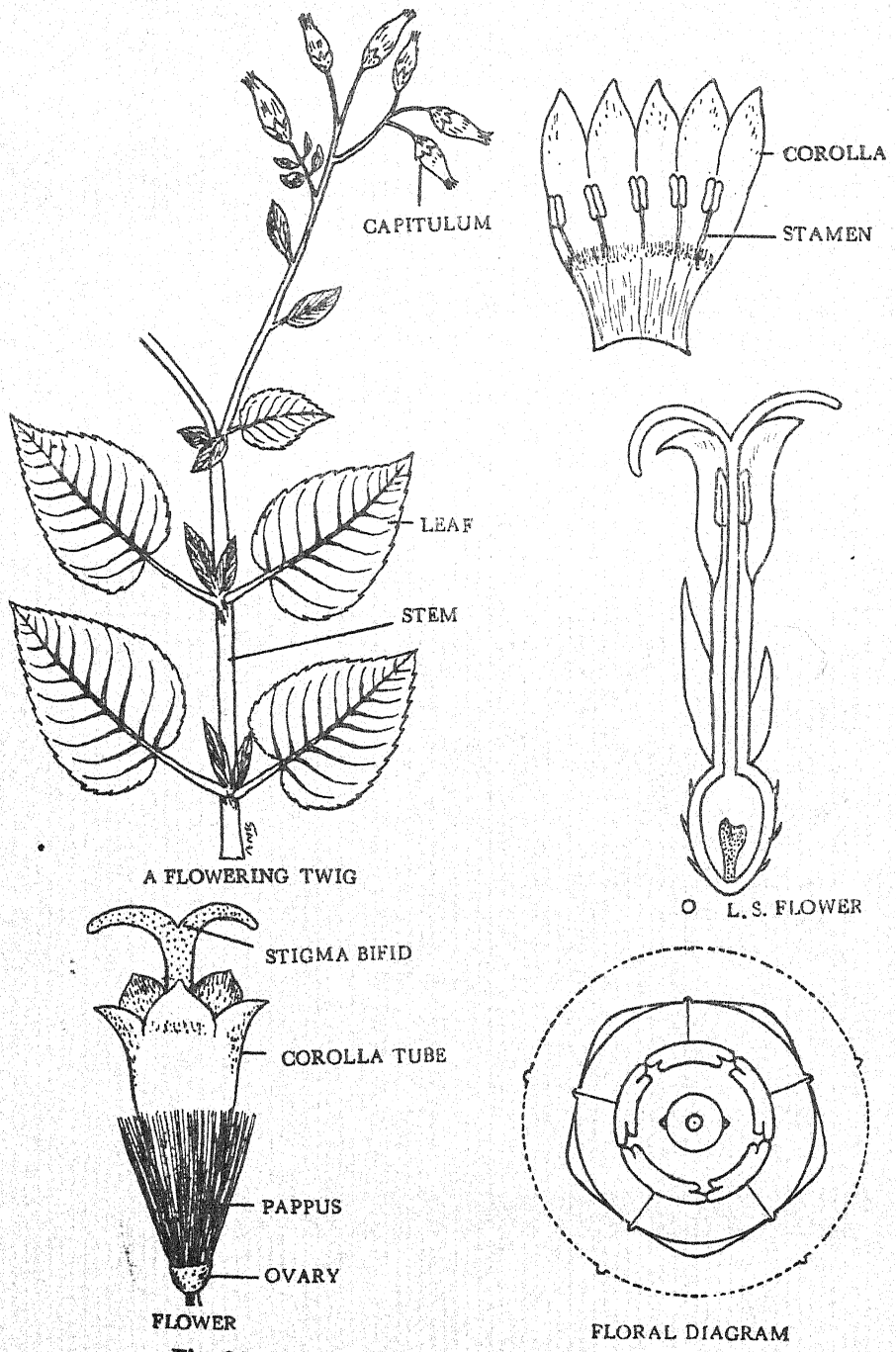


Fig. 224. ***Ageratum conyzoides*** **(Compositae)**

Example 2. *Launaea asplenifolia* (Hindi-Tikchana)

Habit—A wild perennial herb.

Root—Branched tap root.

Stem—Aerial, erect, prostrate, branched, herbaceous, cylindrical, solid to fistular, glabrous, young stem hairy, hairs glaudular, green.

Leaf—Sessile, radical, cauline, simple, existipulate, margin deeply lobed (wavy), toothed, acute, unicostate reticulate.

Inflorescence—Capitulum or head, involucre of bracts present, capitulum ligulate and homozygous.

Flower—Sessile, bracteate, complete, bisexual, ligulate, irregular, zygomorphic, homogamous, epigynous, yellow.

Calyx—Sepals modified into pappus.

Corolla—Petals 5, gamopetalous, toothed, ligulate, valvate, yellow.

Androecium—Stamens 5, syngenesious, epipetalous, filament long, thread-like, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular, basal placentation, ovule one, basal, ovary inferior, style hairy, bifid.

Friut—Cypsella.

Floral Formula

Br, %, $\overset{\diamond}{\varphi}$, K(pappus), $\widehat{C(5)}$, $\widehat{A(5)}$, $\underline{G(\overline{2})}$.

Systematic Position

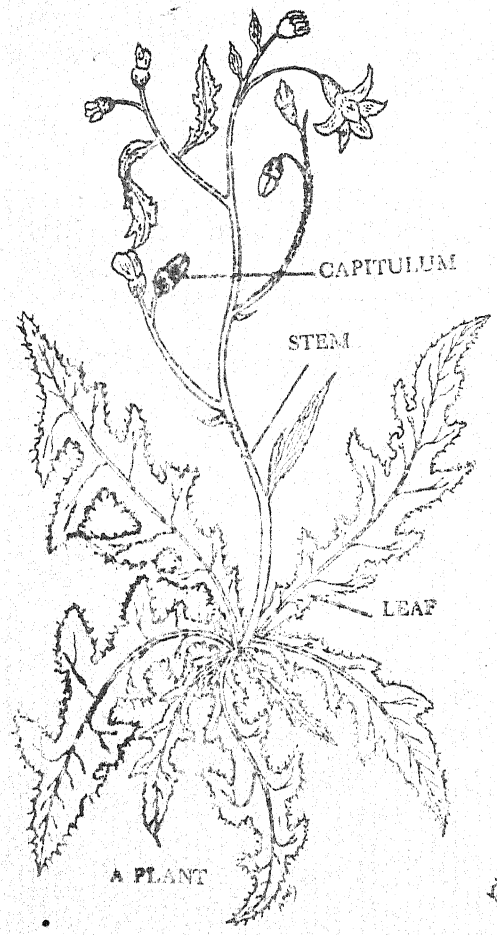
Class—Dicotyledons

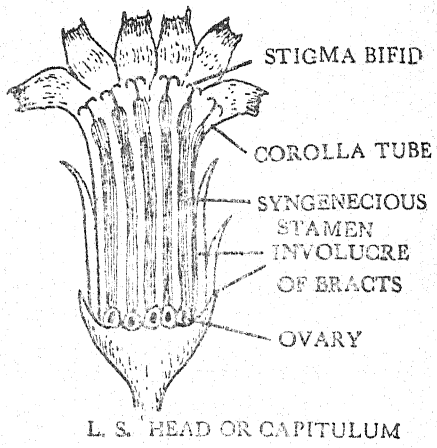
Sub-Class—Gamopetalae

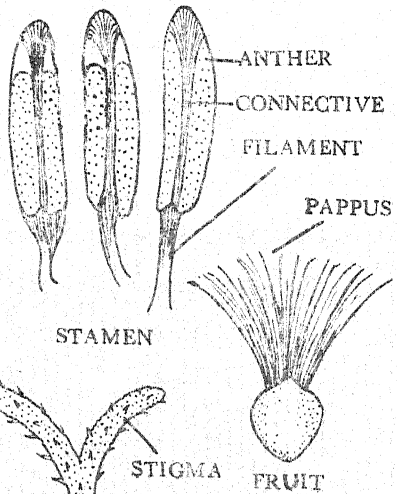
Series—Inferae

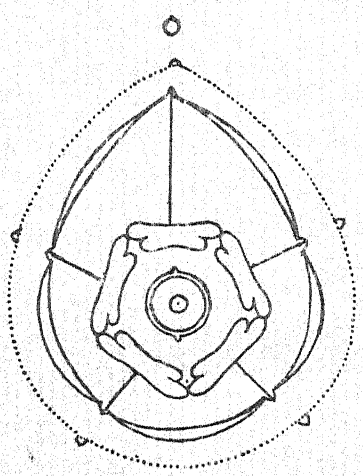
Order—Asterales

Family—Compositae









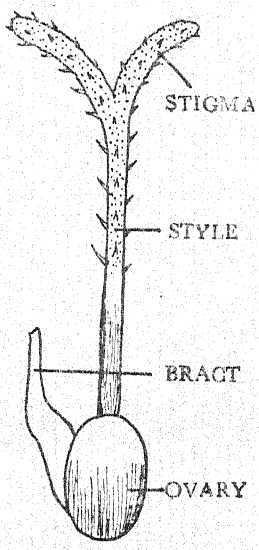


Fig. 223. *Launaea asplenifolia* (Compositae)

Example 3. *Xanthium strumarium* (Hindi—Chota dhatura)

Habit—A wild annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, cylindrical, hairy, brownish-green, spotted.

Leaf—Petiolate, simple, exstipulate, alternate, cordate, lobed, lobes toothed, dentate, acute, unicostate reticulate.

Inflorescence—Capitulum or head, heads in terminal or axillary racemes.

Flower—Bracteate, incomplete, unisexual, actinomorphic, both male and female flowers present.

Male Flower

Calyx—Absent.

Corolla—Petals 5, gamopetalous, tubular, valvate, spinous.

Androecium—Stamens 5, epipetalous, filaments united, filiform, forming column, round the style anthers free, dithecous, basifixed, introrse.

Gynoecium—Highly reduced, pistillode present in the centre.

Female Flower

The involucre of bracts form bicelled urticle, there are 2 flowers, each flower naked.

Calyx—Absent.

Corolla—Absent.

Androecium—Absent.

Gymoecium—Bicarpellary, syncarpous, unilocular, basal placentation, 1 ovule, inferior ovary, style 1, short, stigma fibid.

Fruit—Urticle, spiny, spines hooked.

Floral Formula

Male Flower

$\oplus, \sigma, K_0, \overset{\frown}{C(5)}, \overset{\frown}{A(5)}, G_0.$

Female Flower

$\oplus, \varphi, K_0, C_0, A_0, \underline{\overline{G(2)}}.$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Inferae

Order—Asterales

Family—Compositae

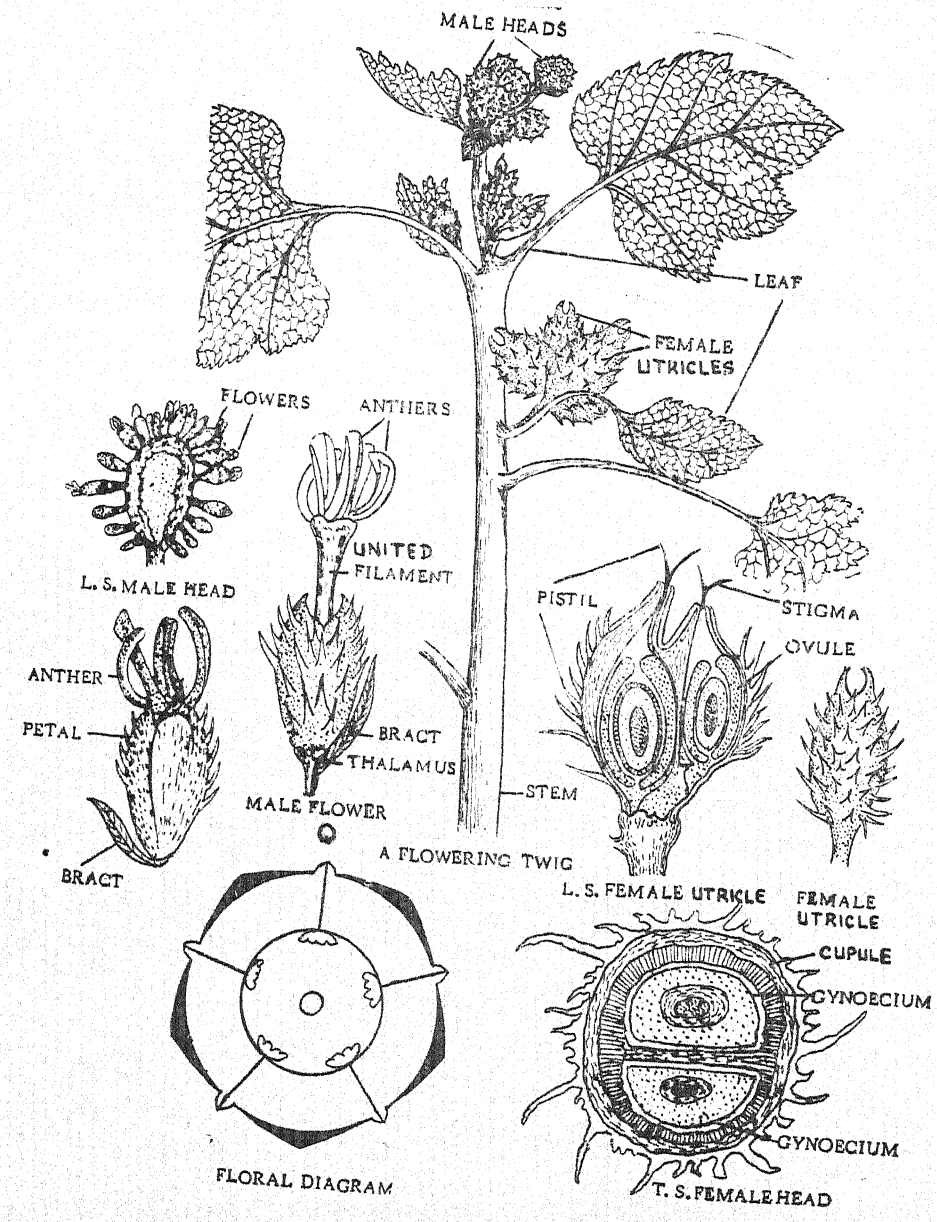


Fig. 226. *Xanthium strumarium* (*Compositae*)

Exampie 4. *Sonchus arvensis*

Habit—A wild annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, hairy, hairs spiny, younger portions with glandular hairs, fistular above, solid below, green.

Leaf—Cauline, sessile, exstipulate, simple, alternate, hastate, amplexicaul, dentate, acute, unicostate reticulate, glabrous.

Inflorescence—Capitulum or head, homozygous, ligulate, involucre of bracts present.

Flower—Sessile, bracteate, complete, bisexual, zygomorphic, pentamerous, cyclic, epigynous.

Calyx—Sepals modified into pappus.

Corolla—Petals 5, gemopetalous, ligulate, valvate, (o/5) arrangement.

Androecium—Stamens 5, syngenesious, epipetalous, filament long, anthers united to form a column round the style, dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular, basal placentation, ovule one, ovary inferior, style long, stigma bifid.

Fruit—Cypsella.

Floral Formula

$$Br,\ \%,\ \male\female,\ K\ \text{pappus},\ C(^{0}/_{5}),\ \overbrace{A_{(5)}},\ G(\underline{2}).$$

Systematic Position

Class—Dicotyledons

Sub-class—Gamopetalae

Series—Inferae

Order—Asterales

Family—Compositae

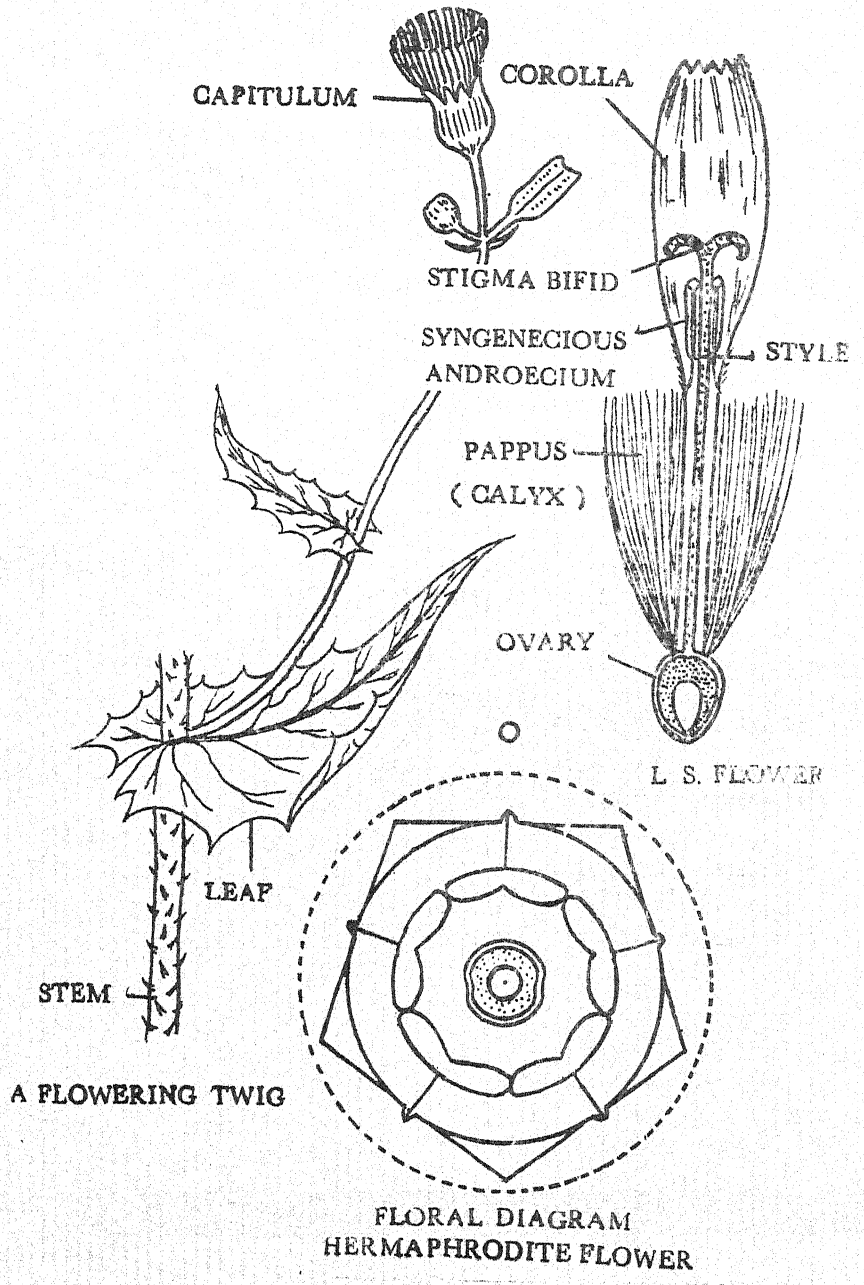


Fig. 227. ***Sonchus arvensis*** **(Compositae)**

APOCYNACEAE

Example 1. *Thevetia peruviana* Syn. *T. nerifolia* (Yellow oleander; Hindi-Peela Kaner)

Habit—A cultivated perennial small tree.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, cylindrical, glabrous, green, milky latex present.

Leaf—Sessile to sub-sessile, exstipulate, simple, whorled, linear, lanceolate, entire, acute, unicostate reticulate, latex present, evergreen.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, large, yellow, hypogynous.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, gamopetalous, tubular, corona present at the throat of the corolla tube, twisted, alternate.

Androecium—Stamens 5, polyandrous, epipetalous, all bent (convergent) towards stigma and adhering to it, filament short, anther dithecous, appendaged, introrse, alternate.

Gynoecium—Bicarpellary, syncarpous, bilocular or tetra locular due to false septum, axile placentation, superior ovary, style 1, long, stigma dome shaped, ovary placed on a honey-disc.

Fruit—Drupe.

Floral Formula

$$Br, \oplus, \delta, \varphi, K_5, \overbrace{C_{(5)}, A_5}, G\ \underline{(2)}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae (carpels 2, ovary superior)

Order—Gentianales

(Leaves opposite, flowers actinomorphic, stamens epipetalous)

Family—Apocynaceae

[1. Cymose inflorescence. 2. Latex present. 3. Stamens 5, epipetalous, not gynandrous. 4. Ovary bicarpellary, free below, united above by the style, ovules one or two in each locule, bilocular or tetralocular.]

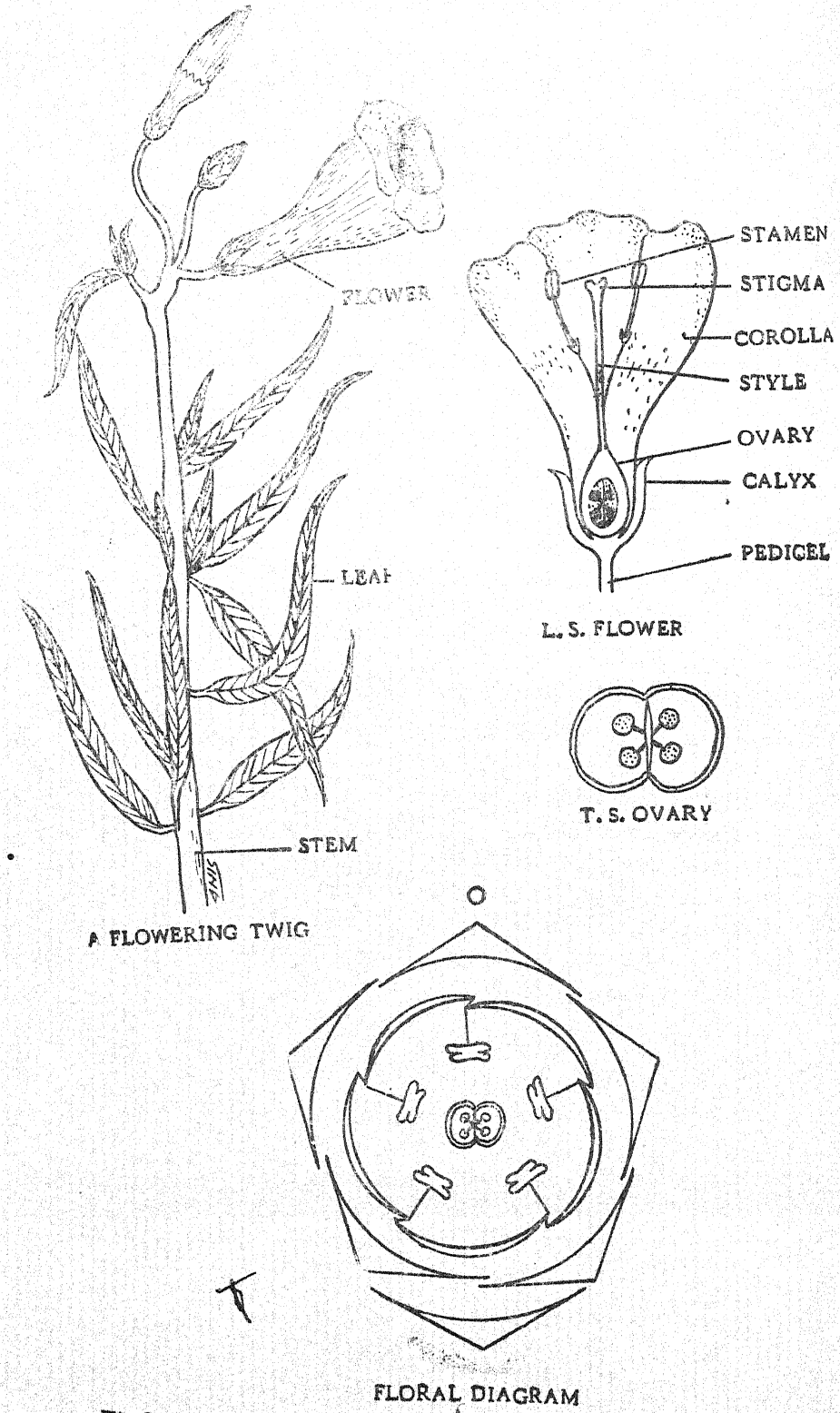


Fig.228. *Thevetia peruviana* (Apocynaceae)

Example 2. *Nerium indicum* (Hindi—Kaner)

Habit—A cultivated perennial shrub or small tree, white latex present in all parts.

Root—Tap root, branched.

Stem—Aerial, erect, branched, woody, solid, cylindrical, glabrous, young part green, white or milky latex present.

Leaf—Petiolate, exstipulate, simple, whorled, elliptical, linear lanceolate, leathery, entire, acute, unicostate, lateral veins almost parallel, confluent subarginally, latex present.

Inflorescence—Cymose, panicle.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, pink-red, large, hypogynous, honey-disc present.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate, slightly fused at extreme base.

Corolla—Petals 5, gamopetalous, salver-shaped (funnel-shaped), tubular corona present at the throat of the corolla, twisted, alternate, pink or red.

Androecium—Stamens 5, epipetalous, polyandrous, flament short, anther dithecous, anthers converge round the stigma, basifixed, appendaged, appandages hairy, alternate.

Gymoecium—Bicarpellary, syncarpous, bilocular, axile placentation, ovules many, superior ovary, honey-disc present, style 1, long, stigma modifide.

Fruit—Follicle

Floral Formula

Br, $\oplus$, $\sigma^{\!\!\!

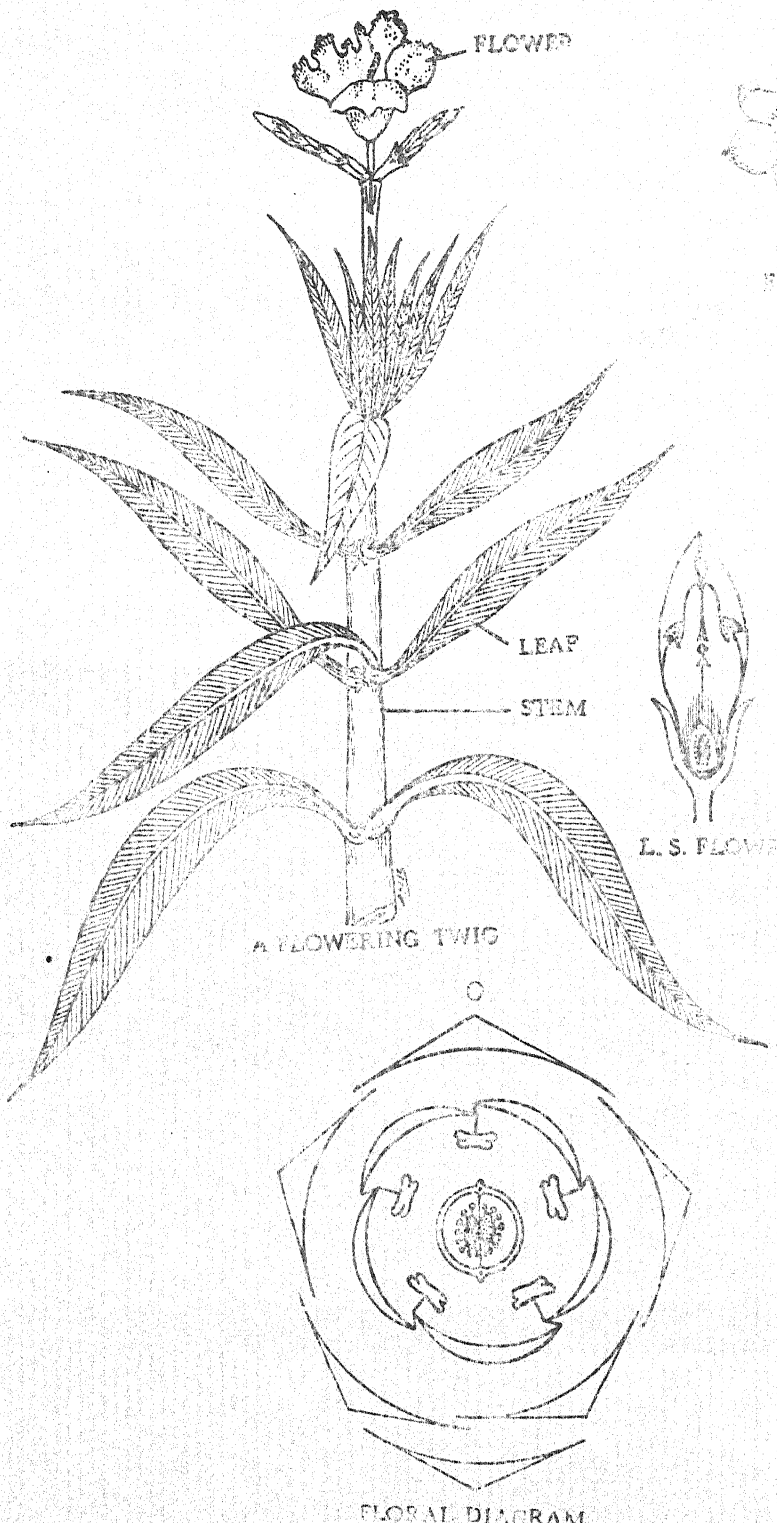


Fig. 229. *Nerium indicum* (Apocynaceae)

Example 3. *Tabernaemontana divaricata*
Syn. *Ervatamia coronaria*
(Crape-jasmine : Hindi—Chandni)

Habit—A cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, woody, solid, cylindrical, glabrous, green above, latex present.

Leaf—Cauline, opposite decussate, petiolate, stipulate, stipules interpetiolar, simple, lanceolate, entire, acute, glabrous, unicostate reticulate, latex present.

Inflorescence—Cymose.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, honey-disc present.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, gamopetalous, tubular, alternate, corona present at the throat of the corolla tube, twisted in bud but valvate in mature flower, white.

Androecium—Stamens 5, polyandrous, epipetalous, joined at the throat of the corolla, filament short, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation, many ovules in each locule, superior ovary, honey-disc present, style 1, long, stigma long, apically bifid, at the tip where carpels are free the ovary is unilocular with marginal placentation.

Fruit—Follicle.

Floral Formula

Br, $\oplus$, φ, σ, K(5), C(5), $\overset{\frown}{A5}$, $\underline{G(2)}$ or $\underline{2}$.

Systematic Position

Class—Dicotyledons

Sub-class—Gamopetalae

Series—Bicarpellatae

Order—Gentianales

Family—Apocynaceae

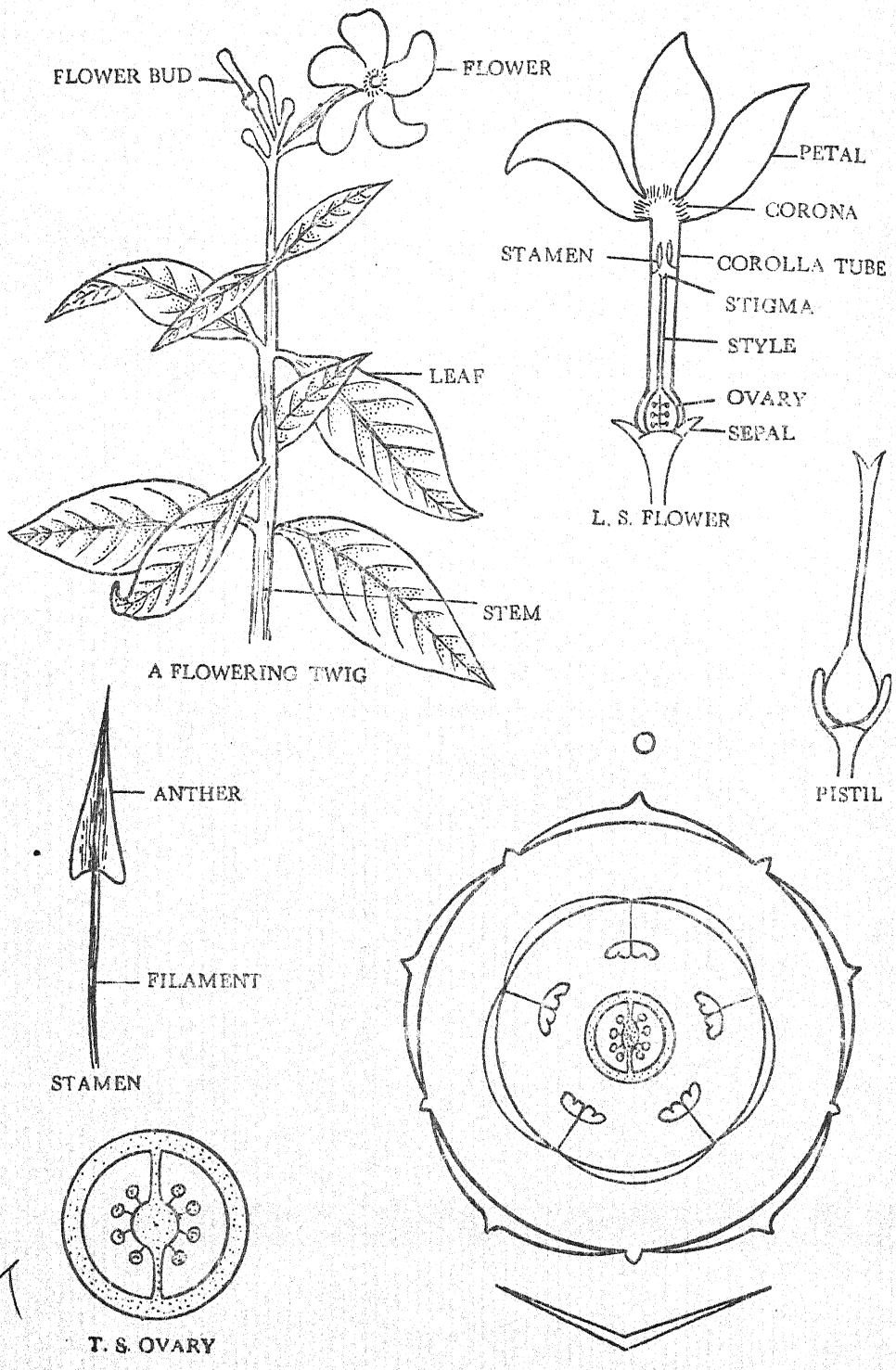


Fig. 230. *Tabernaemontana divaricata* (Apocynaceae)

ASCLEPIADACEAE

Example 1. *Calotropis procera* (Swallow-wart ; Hindi—Madar)

Habit—A wild perennial shrub with milky latex.

Root—Branched tap root.

Stem—Aerial, erect, branched, solid, lower portions woody, smooth, upper portions, herbaceous, covered with wooly hairs, milky latex present, stem pale green.

Leaf—Petiolate, petiole short, exstipulate, simple, opposite decussate, cauline, lanceolate, ovate, entire, acute, unicostate reticulate, leathery, covered with wooly hairs, milky latex present.

Inflorescence—Dichasial axillary umbellate cyme.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, pink, latex present.

Calyx—Sepals 5, polysepalous, ovate, odd sepal posterior, imbricate.

Corolla—Petals 5, gemopetalous, alternate, valvate, 5 corona present, these are laterally compressed, surround staminal tube, each corana having nectary.

Androecium—Stamens 5, modified into *pollinia*, pollinia are waxy and lodged at the angles of *gynostegium* (stigmatic disc), each pollinium is sac-like (having compound pollen grains), two pollinia are attached to a disc or adhesive *corpusculum* through a pair of *translators*.

Gynoecium—Bicarpellary, apocarpous at base, each unilocular, marginal placentation, many ovules in each locule, superior ovary, style 2, joined above to form a stigmatic disc, disc pentangular, the disc along with pollinia is called *gynostegium*.

Fruit—Follicle.

Floral Formula

Br, ⊕, ♀, K5, C(5), $\overline{A5 \text{ pollinia}, \underline{G2}}$.

Systematic Position

Class—Dicotyledons

Sub-class—Gamopetalae

Series—Bicarpellatae

Order—Gentianales

Family—Asclepiadaceae

[1. Flowers solitary or in cymose umbels. 2. Corona present. 3. Pollinia present. 4. Ovary 2, free, united by style. 5. Gynostegium present. 6. Latex present.]

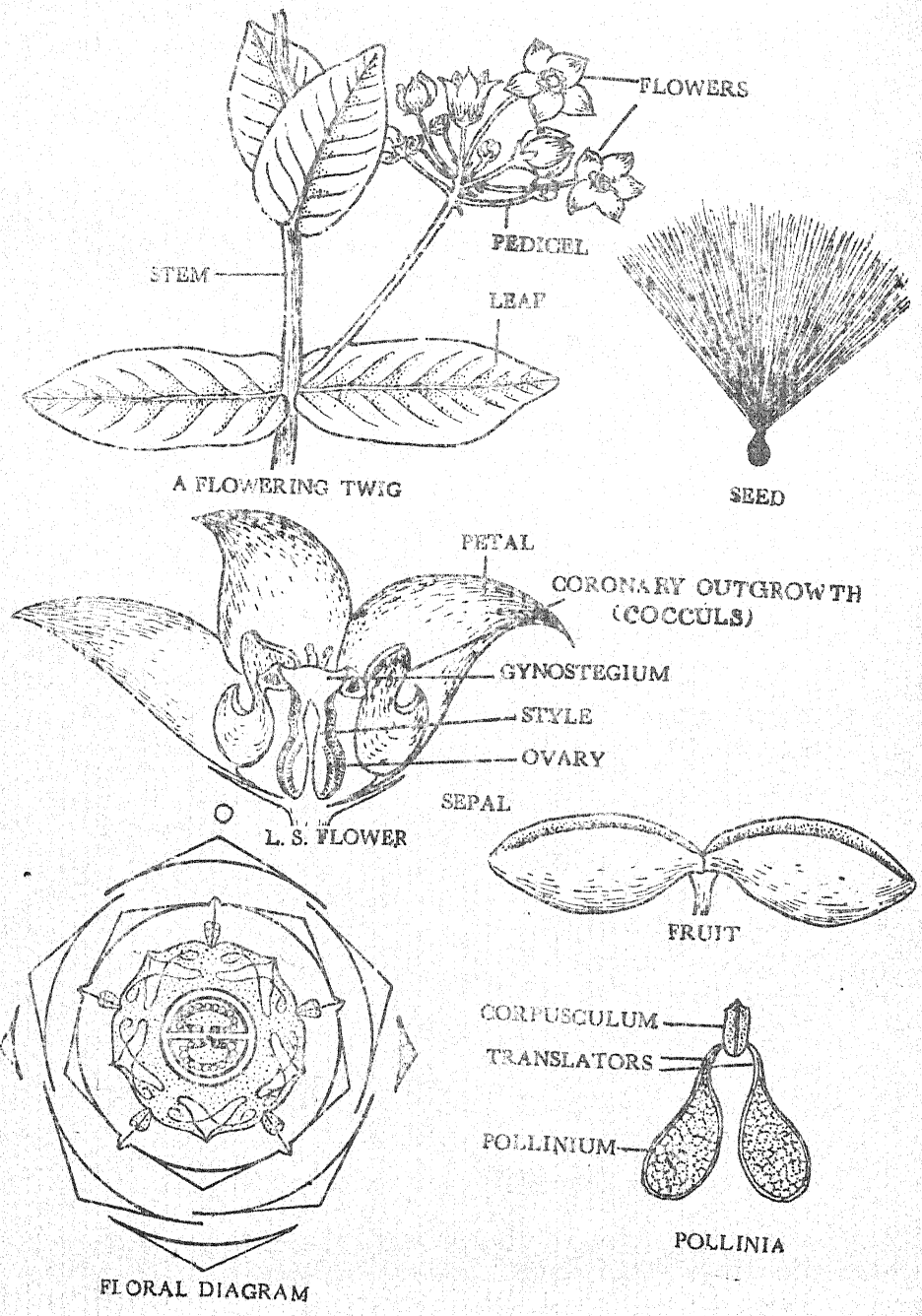


Fig 231. ***Calotropis procera*** **(Asclepiadaceae)**

Example 2. *Asclepias curassavica* (Blood flower ; Hindi—Kakatundi)

Habit—A cultivated perennial herb, latex present.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, lower portion woody, solid, cylindrical, glabrous, latex present.

Leaf—Cauline, opposite decussate, petiolate, simple, lanceolate, entire, acute, glabrous, unicostate reticulate.

Inflorescence—Extra axillary umbellate cyme.

Flower—Pedicellate, bracteate, complete bisexual, regular, actinomorphic pentamerous, cyclic, hypogynous, brightly coloured, pink or purple yellow.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, gamopetalous, drooping downwards, corona 5, surrounding the staminal tube, nectary present; nectary horn-like petal twisted, alternate to sepals, purple-yellow.

Androecium—Stamens 5, modified into pollinia, lodged on the angles of gynostegium.

Gynoecium—Bicarpellary, apocarpous at base, united above, each ovary unilocular, many ovules in each locule, marginal placentation, superior ovary, style 2, join to form a pentagonal stigmatic disc, disc with pollinia is called gynostegium.

Fruit—Follicle

Floral Formula

$$Br, \oplus, \mathrm{\overset{\sigma}{\underset{\varphi}{}}}, K_5, C_{(5)}, \overbrace{A_5 \text{ pollinia}}, \underline{G_2}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Gentianales

Family—Asclepiadaceae

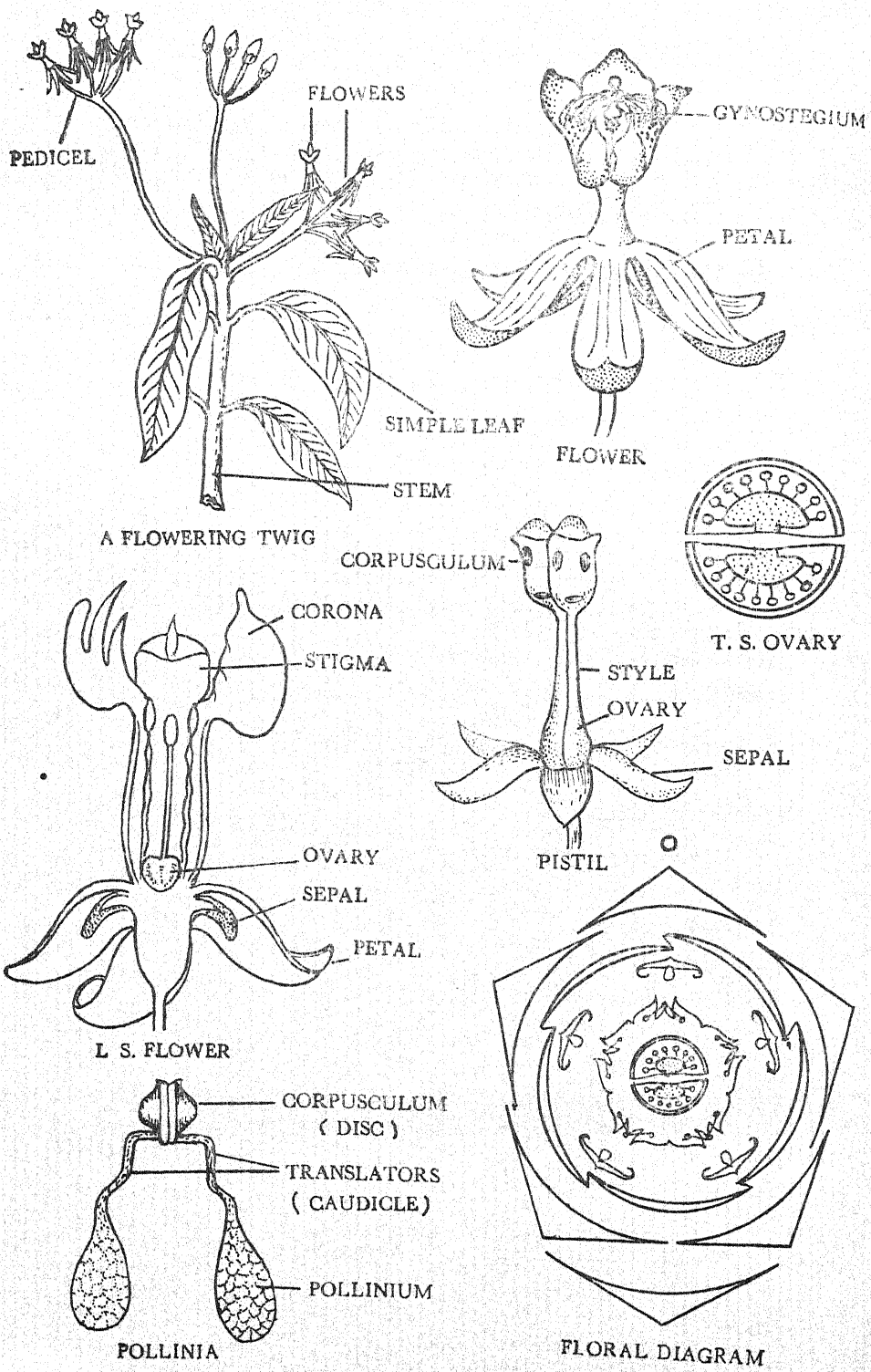


Fig. 232. *Asclepias curassavica* (Asclepiadaceae)

CONVOLVULACEAE

Example 1. *Cuscuta reflexa* (Dodder ; Hindi-Amarbel)

Habit—A wild, twining, parasitic, perennial herb.

Root—Absent.

Stem—Aerial, twining, climbing, weak, parasitic, branched, herbaceous, yellow, solid, forms and sends haustoria to the stem of the host plant to suck up food material.

Leaf—Absent.

Inflorescence—Cymose, flowers in clusters (fascicle).

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, white.

Calyx—Sepals 5, polysepalous, slightly fused at base, odd sepal posterior, imbricate.

Corolla—Petals 5, polypetalous, alternate, twisted, tubular, campanulate, deciduous, corona-like structures present at the base, white.

Androecium—Stamens 5, polyandrous, epipetalous, filament short, anther dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation, ovules 2—4 in each locule, superior ovary, style reduced or absent, stigma bilobed, lobes reflexed, ovary placed on a red coloured nectariferous disc (honey disc).

Fruit—Capsule.

Floral Formula

Br, $\oplus$, $\varsigma^{\mathfrak{Q}}$, K_5, $\overbrace{C_{(5)}}$, A_5, $\underline{G(2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Polemoniales

[1. Leaves exstipulate, alternate.

2. Flowers actinomorphic.

Family—Convolvulaceae

[1. Ovary bicarpellary, syncarpous, bilocular, axile placentation 2 ovules in each locule, superior ovary.

2. Ovary placed on a honey disc.

3. Fruit is Capsule.]

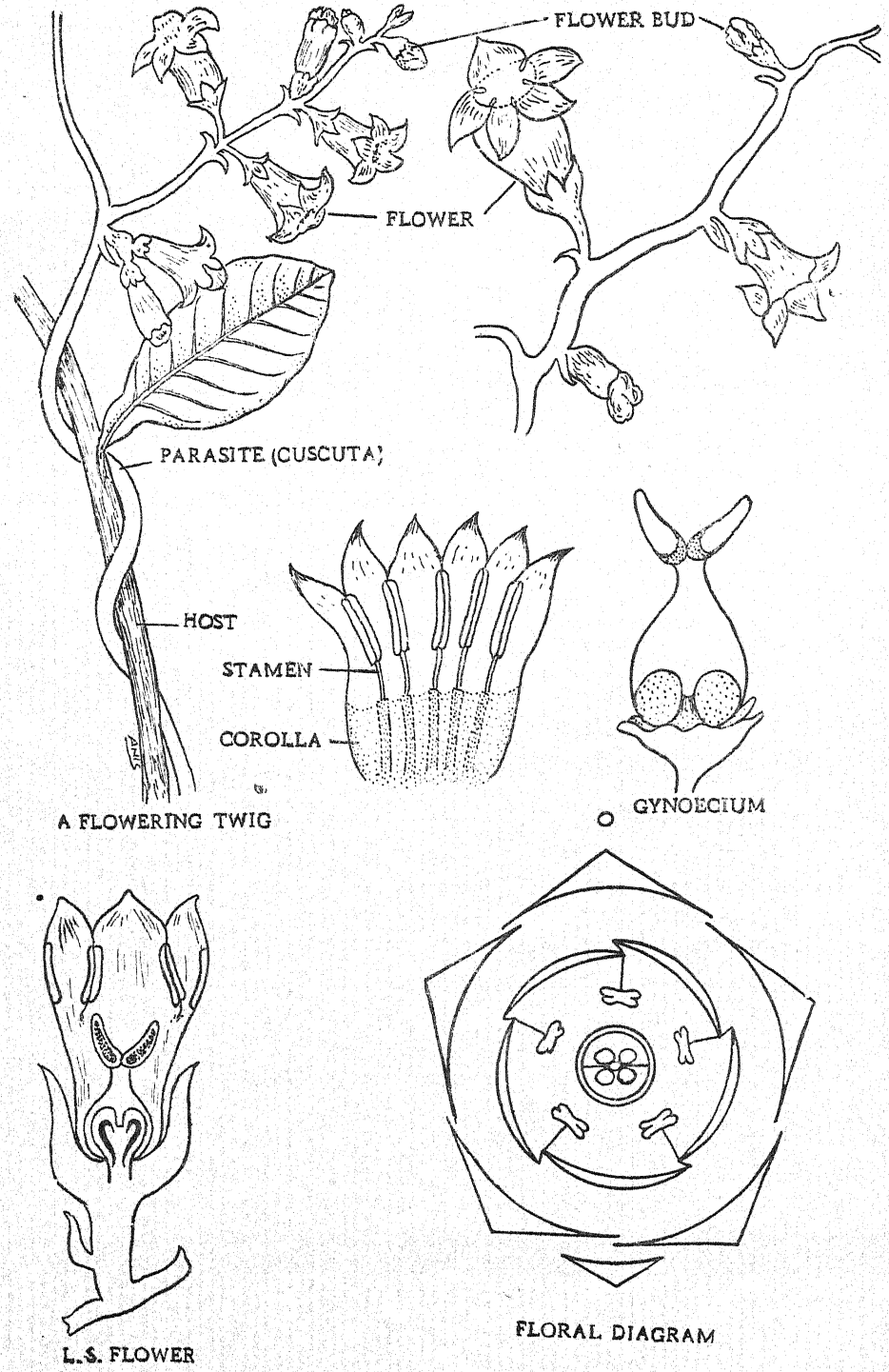


Fig. 233. ***Cuscuta reflexa*** **(Convol vulaceae).**

Example 2. *Ipomoea fistulosa* Syn. *I. carnea*
(Hindi-Ubchak)

Habit—A wild perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, herbaceous, woody (lower portion), fistular, glabrous, green.

Leaf—Cauline, petiolate, petiole long, simple, alternate, exstipulate, cordate, entire, acute, glabrous, unicostate reticulate venation.

Inflorescence—Dichasial cyme.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, actinomorphic, regular, pentamerous, cyclic, hypogynous, pink, tubular (infundibuliform).

Calyx—Sepals 5, polysepalous, shigltly fused at base, odd sepal posterior, imbricate, persistent.

Corolla—Petals 5, gamopetalous, alternate to sepals, induplicate, valvate, twisted in bud, tubular, infundibuliform, pink.

Androecium—Stamens 5, polyandrous, alternate to petals, epipetalous, filaments long, unequal, 3 small, 2 large, anthers sagitate, dithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, 2 ovules in each locule, placentation axile, ovary superior, placed on a honey disc, style long, stigma dumble-shaped.

Fruit—Capsule.

Floral Formula

Br, ⊕ ♂, K(5), C(5)⁀A5, $G_{(2)}$.

Systematic Positi on

Class—Dicotyledons
Sub-class—Gamopetalae
Series—Bicarpellatae
Order—Polemoniales
Family—Convolvulaceae

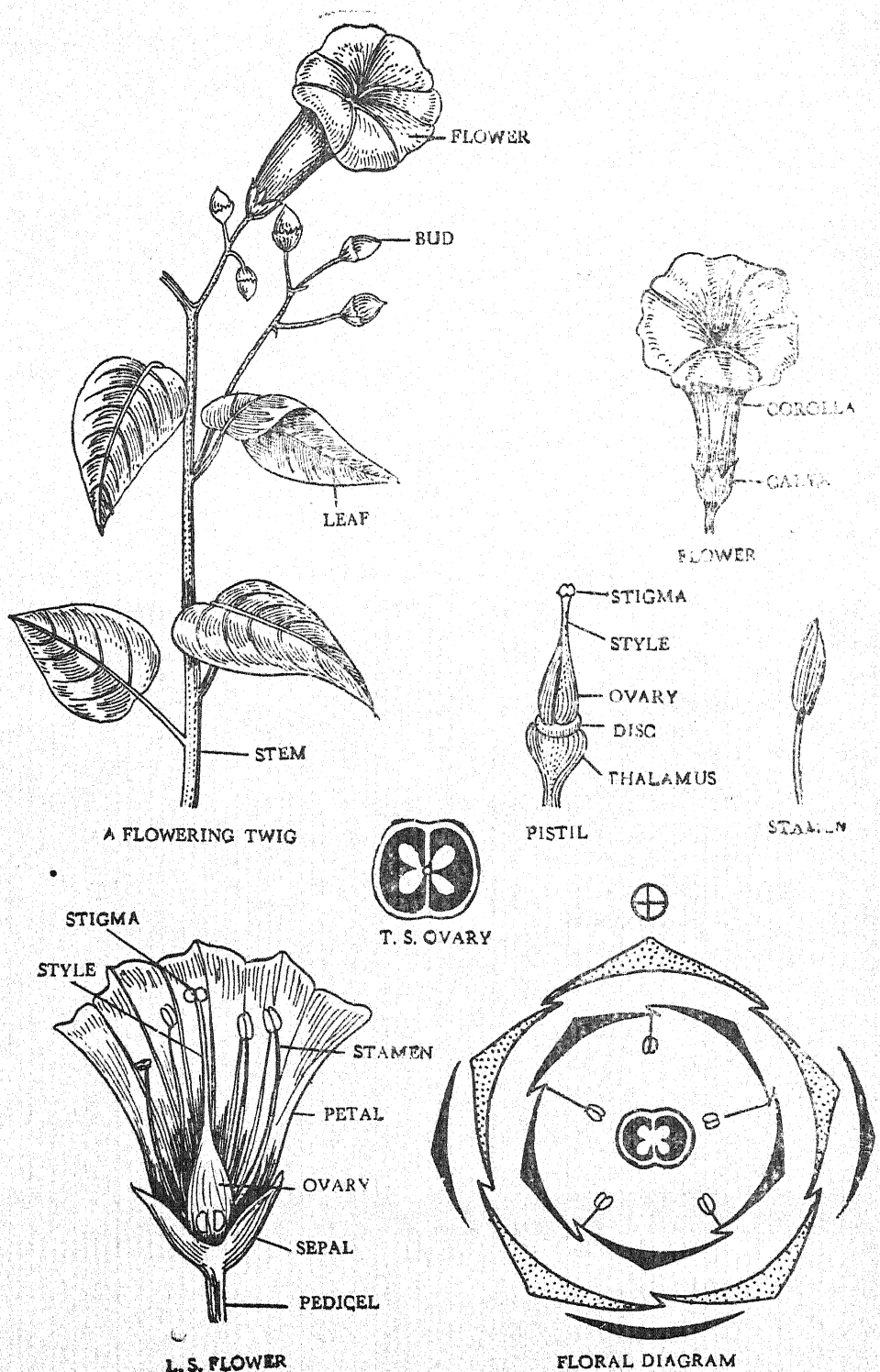


Fig. 234. *Ipomoea fistulosa* (Convolvulaceae)

Example 3. *Convolvulus pluricaulis*
(Hindi—Pushpashankhi)

Habit—A wild prostrate perennial spreading herb.

Root—Branched tap root.

Stem—Prostrate, aerial, branched, hairy, hairs silky, solid, green, herbaceous.

Leaf—Cauline, simple, subsessile, alternate, exstipulate, oblong or linear-oblanceolate, entire, acute, unicostate reticulate, hairy.

Inflorescence—Solitary axillary.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, white.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate, hairy, persistent.

Corolla—Petals 5, gamopetalous, twisted, alternate to sepals, tubular, funnel shaped, white or pale-rose.

Androecium—Stamens 5, polyandrous, alternate to petals, epipetalous, filament long, filiform, anthers dithecous, dorsifixed, slightly exerted.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation, 2 ovules in each locule, superior ovary, placed on a honey disc, style long, bifurcating into two linear hairy stigmas.

Fruit—Capsule.

Floral Formula

Br, ⊕, ♂, ♀, K5, C(5) A5, G(2).

Systematic Position

Class—Dicotyledons

Sub-class—Gamopetalae

Series—Bicarpellatae

Order—Polemoniales

Family—Convolvulaceae

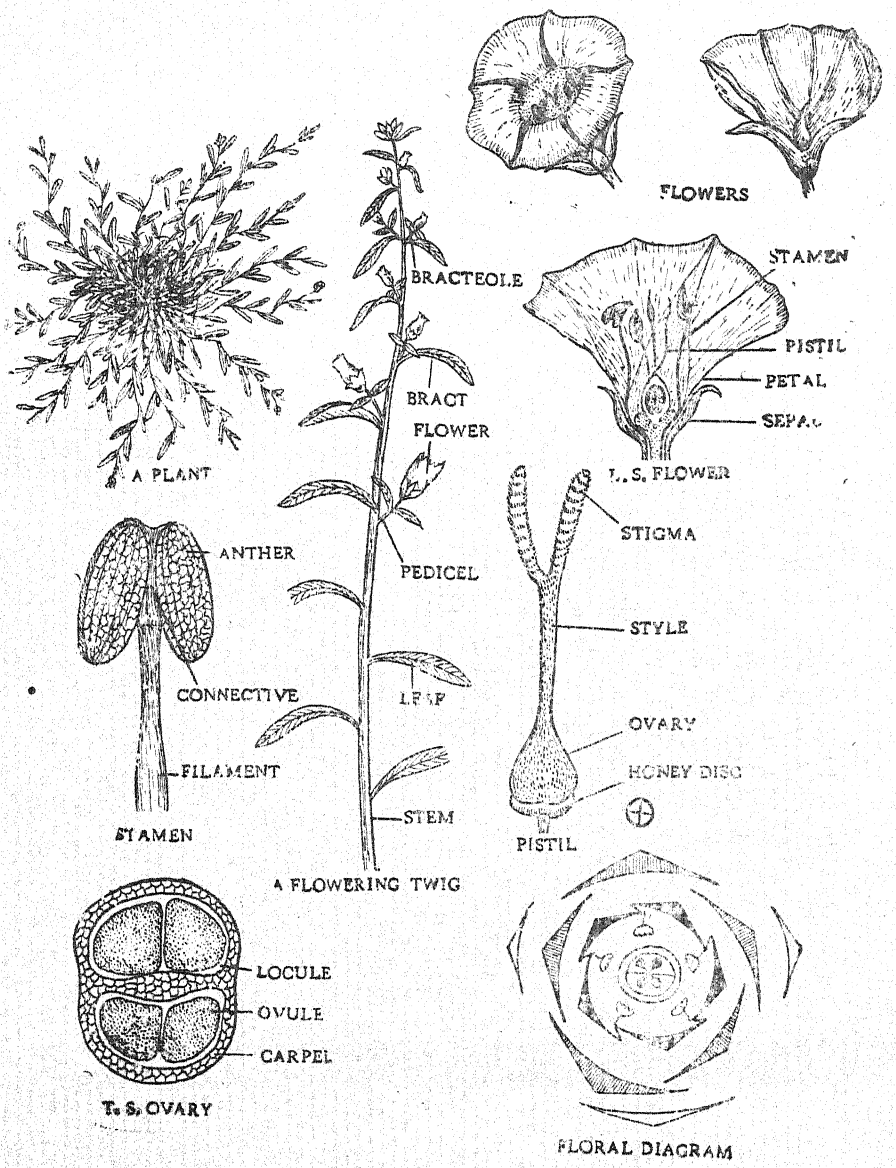


Fig. 235. ***Convolvulus pluricaulis*** **(Convolvulaceae)**

Example 4. *Porana paniculata*

(Bridal creeper ; Hindi-Safed bel)

Habit—A perennial climbing herb.

Root—Branched tap root.

Stem—Aerial, climbing, branched, hairy or tomentose, cylindrical, herbaceous, woody, solid, younger stems green.

Leaf—Cauline, simple, petiolate, exstipulate, pubescent, alternate, ovate or cordate, entire, acute, unicostate reticulate.

Inflorescence—Cymose, in panicles.

Flower—Pedicellate, bracteate, bracteolate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, white.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, gamopetalous, alternate to sepals, valvate, tubular, campanulate, white.

Androecium – Stamens 5, polyandrous, epipetalous, alternate to petals, filament filiform, anther bithecous, basifixed, introrse.

Gynoecium—Bicarpellary, syncarpous, bilocular, 2 ovules in each locule, axile placentation, superior ovary, ovary placed on a honey disc, style short, stigma bilobed.

Fruit—Capsule.

Floral Formula

$$\text{Br},\ \oplus,\ \overset{\mathfrak{\sigma}}{\underset{+}{}},\ K_5,\ \overbrace{C_{(5)}},\ A_5,\ \underline{G_{(2)}}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Polemoniales

Family—Convolvulaceae

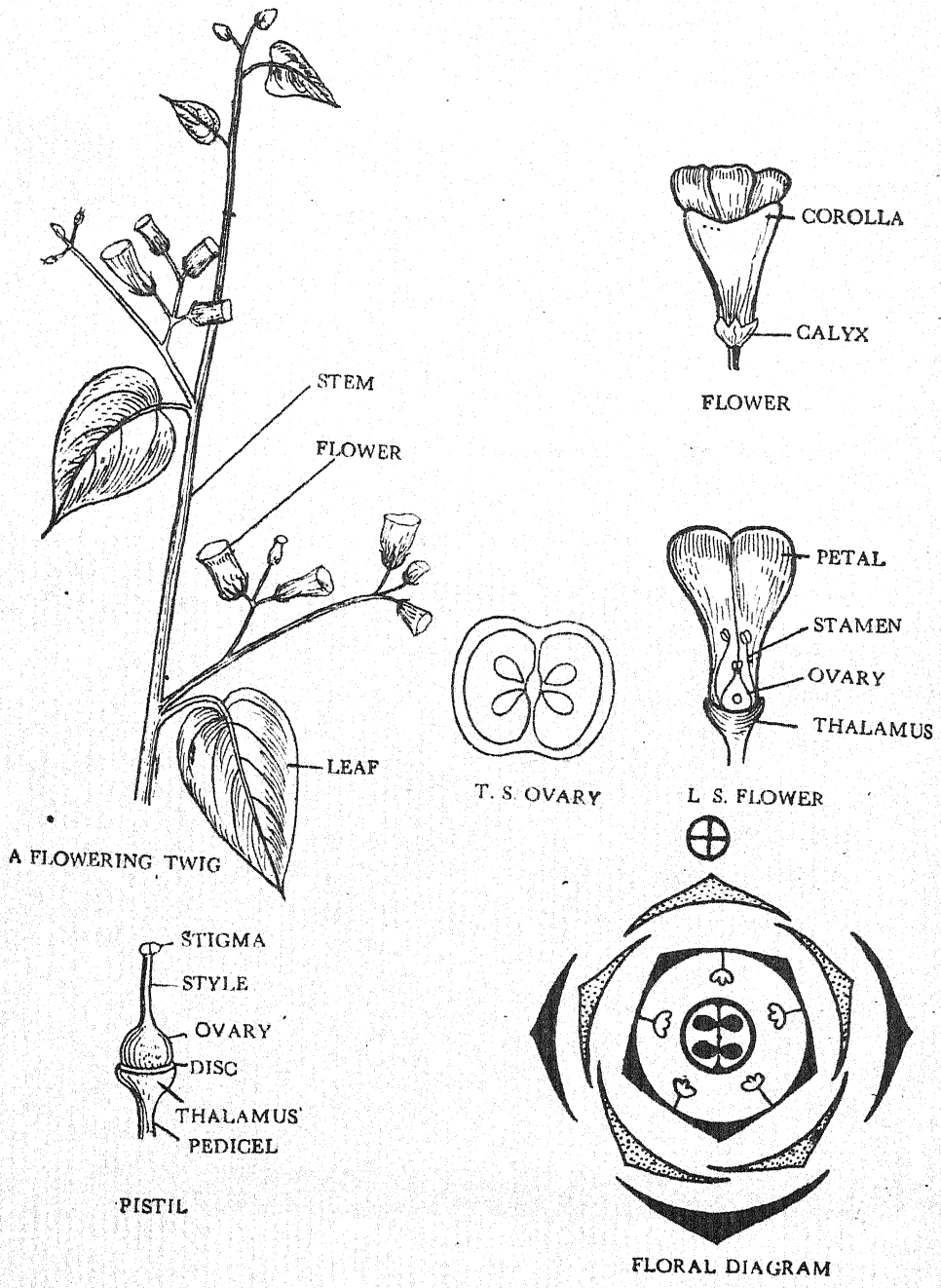


Fig. 236. *Porana paniculata* (Convolvulaceae)

SOLANACEAE

Example 1. *Solanum nigrum*

(Black night shade ; Hindi—Makoi)

Habit—A wild annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, herbaceous, green, solid, rough.

Leaf—Petiolate, exstipulate, cauline, petiole adnate with stem, alternate, upper leaves sub-opposite, ovate, entire, acute, unicostate reticulate.

Inflorescence—Extra-axillary umbellate cyme.

Flower—Pedicellate, ebracteate, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, white.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate, persistent.

Corolla—Petals 5, gamopetalous, alternate to sepals, valvate, campanulate, white.

Androecium—Stamens 5, polyandrous, epipetalous, alternate to petals, filament short, anther dithecous, conniving, basifixed, dehisce by apical pore.

Gynoecium—Bicarpellary, syncarpous, bilocular, axile placentation many ovules in each locule, placenta swollen, ovary obliquely placed, superior, placed on a honey-disc, style 1, long, stigma bilobed or 2.

Fruit—Berry.

Floral Fomula

$$Br,\ \oplus,\ \sigma^{\mathfrak{P}},\ K_{(5)},\ \overset{\frown}{C_{(5)}},\ A_5,\ \underline{G_{(2)}}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Polemoniales

Family—Solanaceae

[1. Flowers solitary or cymose (umbel).

2. Ovary superior, placed on a honey-disc, placenta swollen and ovary obliquely placed.

3. Fruit berry or capsule.]

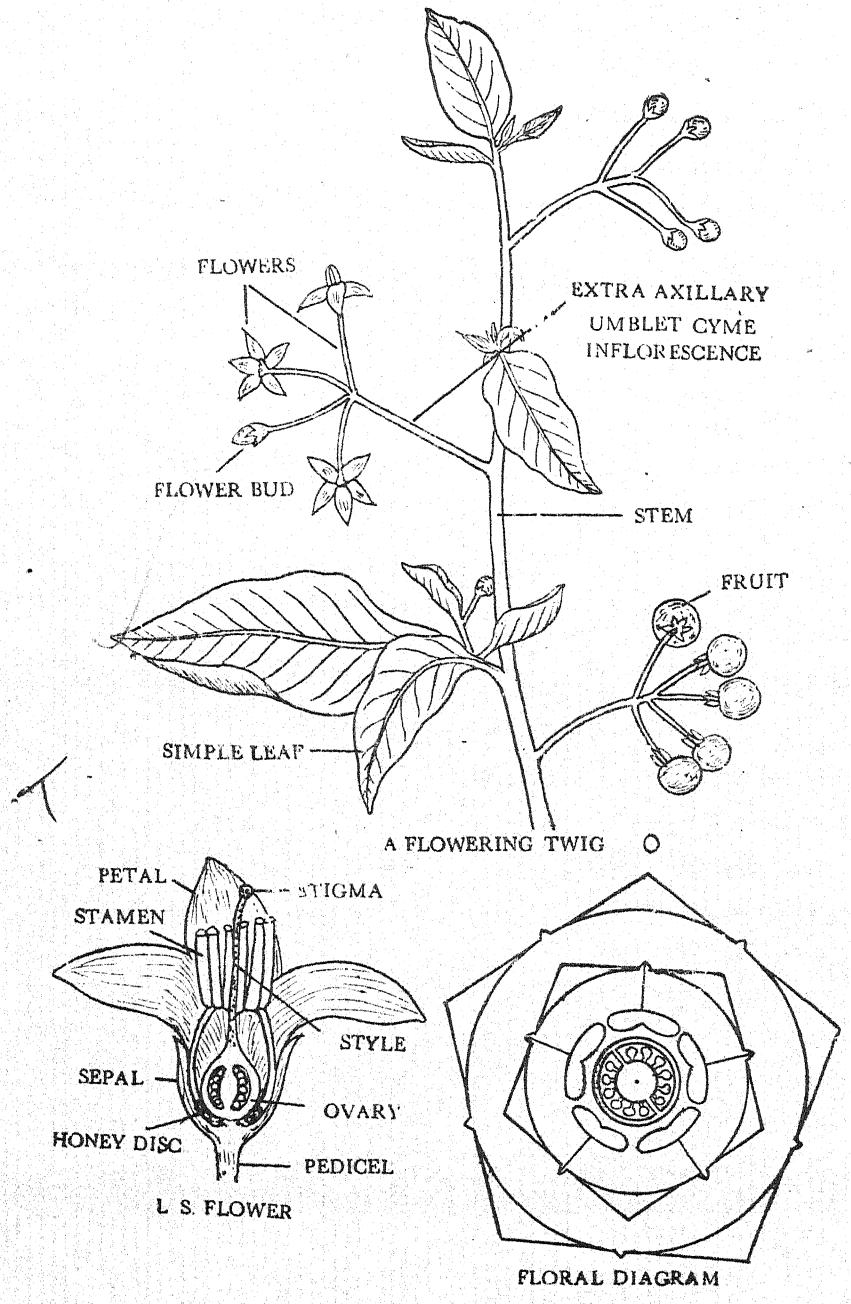


Fig. 237. ***Solanum nigrum*** **(Solanaceae)**

Example 2. *Solanum xanthocarpum*

(Hindi—Kateli or Bhatkataiya)

Habit—A wild perennial herb.

Root—Branched tap root.

Stem—Aerial, erect to prostrate, prickly, branched, cylindrical, green.

Leaf—Petiolate, exstipulate, simple, alternate, margin deeply serrate, prickly, acute, unicostate reticulate.

Inflorescence—Extra-axillary shortly peduncled cyme.

Flower—Pedicellate, ebracteate, pedicel prickly, complete, bisexual, regular, actinomorphic, pentamerous, cyclic, hypogynous, bluish-purple.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, gemopetalous, lobes prominent, alternate to sepals, twisted, bluish-purple.

Androecium—Stamens 5, polyandrous, epipetalous, alternate to petals, filament short, anther yellow, dithecous, basifixed, dehisce by apical pore.

Gynoecium—Bicarpellary, syncarpous, bilocular, many ovules in each locule, axile placentation, placenta swollen, ovary obliquely placed, superior, placed on a honey disc, style 1, stigma bilobed.

Fruit—Berry.

Floral Formula

$\oplus$, δ, $\mathrm{K}_{(5)}$, $\overset{\frown}{\mathrm{C}_{(5)}, \mathrm{A}_{5}}$, $\underline{\mathrm{G}_{(2)}}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Polemoniales

Family—Solanaceae

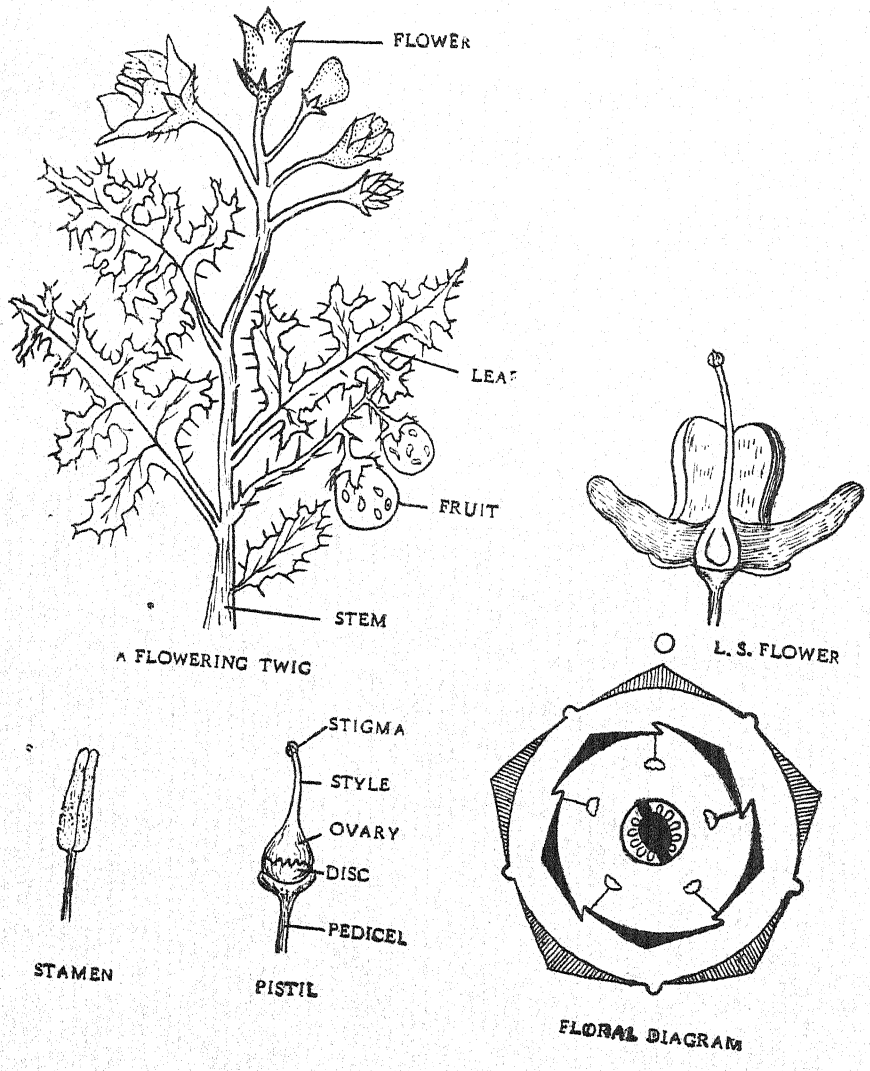


Fig. 238. *Solanum xanthocarpum* (Solanaceae)

SCROPHULARIACEAE

Example 1. *Lindenbergia indica* Syn. *L. urticaefolia*

Habit—An annual wild herb, grows mostly on old brick-walls and neglected places.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, cylindrical, glabrous, green.

Leaf—Petiolate, opposite decussate, exstipulate, simple, ovate, crenate-serrate, acute, margin hairy, unicostate recticulate

Inflorescence—Solitary axillary.

Flower—Pedicellate, pedicel short, bracteate, complete, bisexual, irregular, zygomorphic, bilipped, pentamerous, cyclic, hypogynous, yellow.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, imbricate, tubular, hairy, persistent.

Corolla—Petals 5, gamopetalous, alternate to sepals, odd petal anterior, bilipped, posterior upper lip short, narrow, bilobed, lower lip 3 lobed, large, spreading, corolla tube hairy, red-purple dots on the inner side, imbricate, yellow.

Androecium—Stamens 4, polyandrous, epipetalous, posterior stamen abortive, didynamous, connective elongated, anther dithecous, filament long.

Gynoecium—Bicarpellary, syncarpous, bilocular, ovary medianaly placed (transversely placed), many ovules in each locule, placenta swollen placentation axile, ovary superior, style 1, long, stigma capitate-fimbriate.

Friut—Capsule.

Floral Formula

$$Br,\ \%,\ \mathbb{Q}^{\mathcal{J}},\ K_{(5)},\ \overbrace{C_{(2/3)}},\ A_4 \text{ or } {}_{2+2},\ \underline{G_{(2)}}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

[1. Corolla tube bilobed.

2. Stamens 2 or 4, epipetalous. 3. Ovary 1—4 locular.]

Family—Scrophulariaceae

[1. Leaves opposite, exstipulate. 2. Sepals 5, gamosepalous.

3. Stamens didynamous, 4. Ovary bilocular, fruit capsule.]

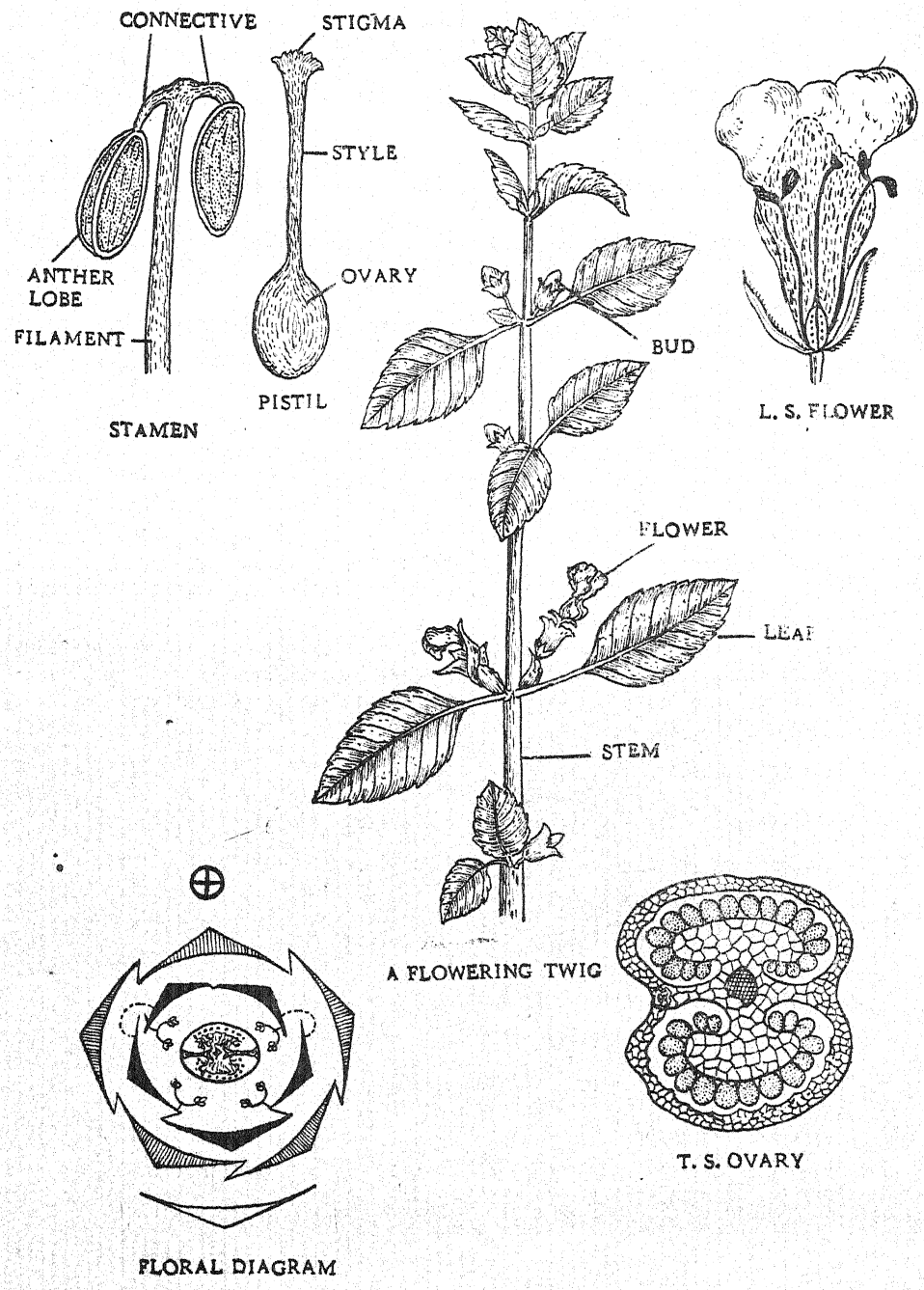


Fig. 239. *Lindenbergia indica* (Scrophulariaceae)

Example 2. *Scoparia dulcis*

Habit—A wild perennial herb or under shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, herbaceous, glabrous, green.

Leaf—Cauline, petiolate, exstipulate, simple, opposite decussate, whorled at apex, pinnately lobed, lanceolate, serrate, acute, unicostate reticulate.

Inflorescence—Solitary axillary or in pairs.

Flower—Pedicellate, bracteate, complete, bisexual, regular, actinomorphic, small, tetramerous, cyclic, hypogynous, white.

Calyx—Sepals 4, gamosepalous, tubular, oblong, imbricate.

Corolla—Petals 4, gamopetalous, corolla tube short, densely bearded, imbricate, alternate to sepals, white.

Androecium—Stamens 4, polyandrous, epipetalous, alternate to petals, subequal, anther dithecous, dorsifixed.

Gynoecium—Bicarpellary, syncarpous, bilocular, carpels placed medianaly, many ovules in each locule, placenta swollen, axile placentation, ovary superior, style long, stigma flat or notched, persistent.

Fruit—Capsule with persistent stigma.

Floral Formula

$Br, \oplus, \overset{+}{\circlearrowleft}, K(4), \overset{\frown}{C(4)}, A4, \underline{G(_2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

Family—Scrophulariaecae

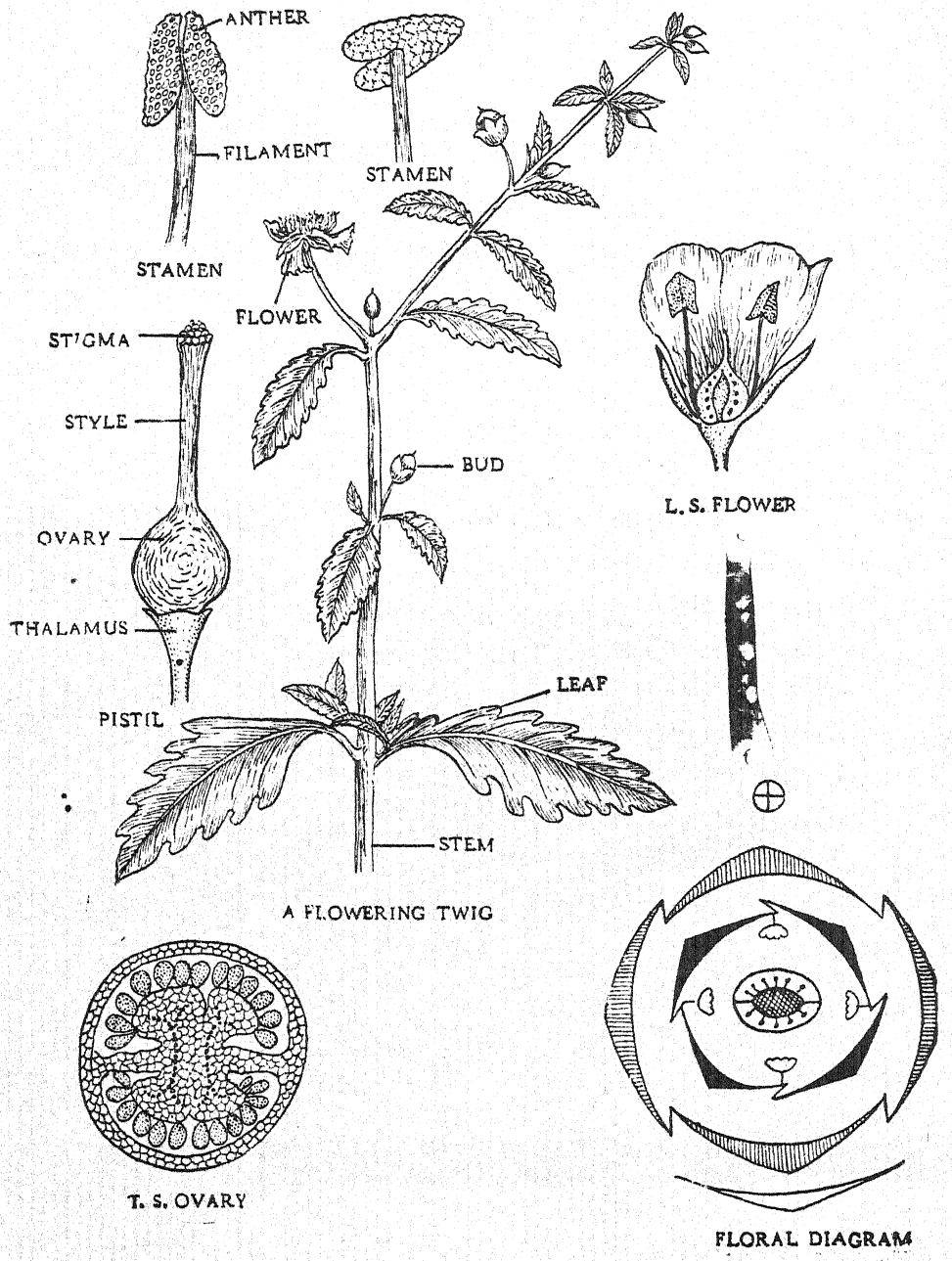


Fig. 240. *Scoparia dulcis* (Scrophulariaceae)

Example 3. *Russelia equisetiformis* Syn. *R. juncea* (Coral plant)

Habit—An ornamental cultivated perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, woody, solid, angular, ribbed longitudinally, glabrous, green.

Leaf—Cauline, petiolate, simple, small, exstipulate, whorled, ovate, serrate, acute, glabrous, unicostate reticulate, caducous.

Inflorescence—Terminal or axillary panicle cyme.

Flower—Pedicellate, bracteate, complete, bisexual, irregular, zygomorphic, cyclic, pentamerous, red, hypogynous.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, gamopetalous, altenate to sepals, imbricate, tubular, red, bilipped, upperlip small, bilobed, lower lip large, 3 lobed.

Androecium—Stamens 4, fertile or perfect, posterior stamen abortive seen as staminode, polyandrous, epipetalous, didynamous, filament hairy, anther dithecous, dorsifixed.

Gymoecium—Bicarpellary, syncarpous, bilocular, many ovules in each locule, placentation axile, placenta swollen, carpels placed medianaly, ovary superior, style 1, long, stigma linear.

Fruit—Capsule.

Floral Formula

Br, %, $\overset{+}{\sigma}$, K(5), C(2/3), $\widehat{A2}$+, $\underline{G}_{(2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

Famiiy—Scrophulariaceae

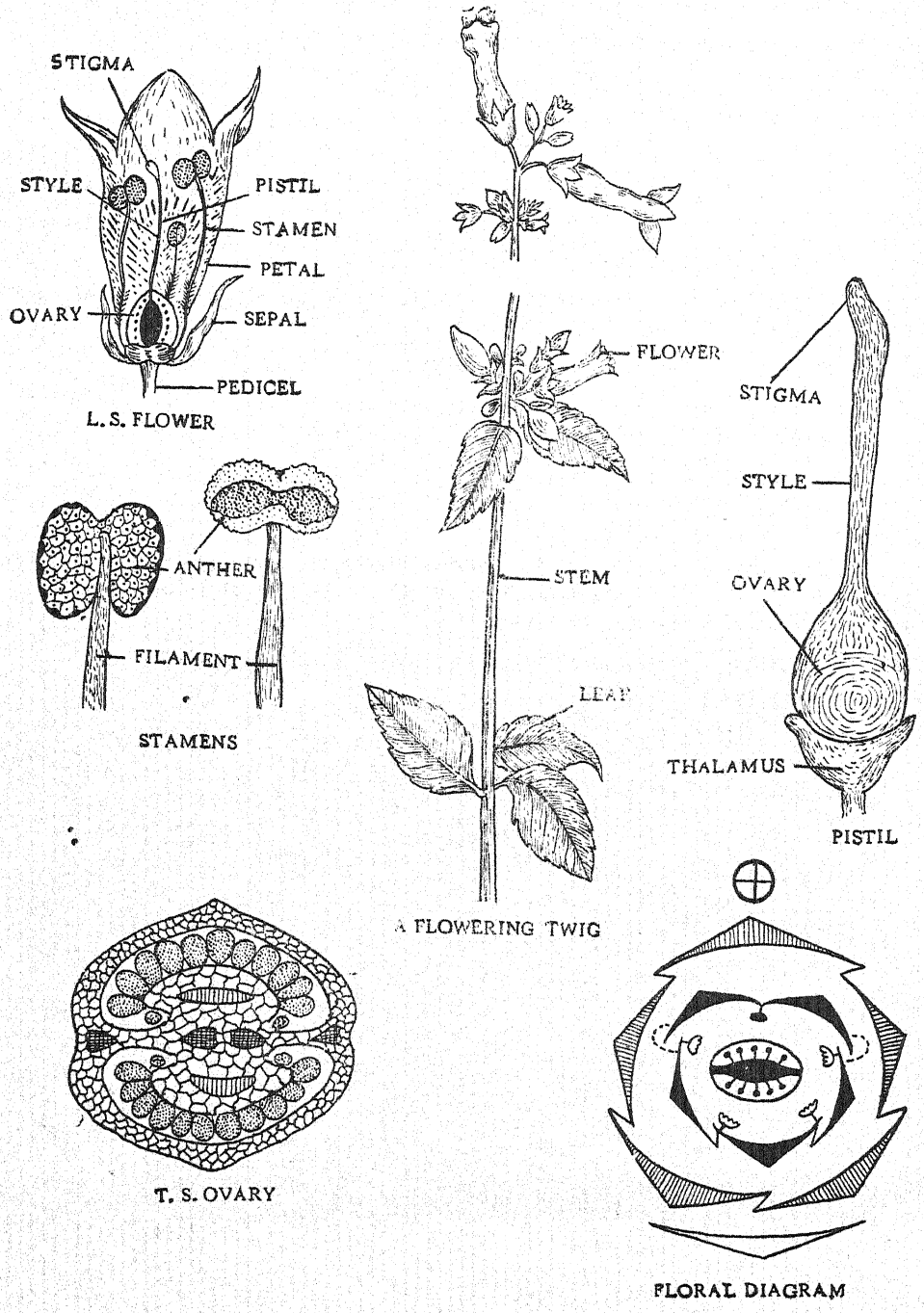


Fig. 241. *Russelia equisetiformis* (Scrophulariaceae)

ACANTHACEAE

Example 1. *Adhatoda vasica* Syn. *Justicia adhatoda*
(Hindi-Roosa)

Habit—A wild, perennial, evergreen, undershrub.

Root—Taproot, branched.

Stem—Aerial, erect, branched, cylindrical to quadrangular, swollen at nodes, woody, solid, glabrous.

Leaf—Cauline, petiolate, exstipulate, simple, opposite decussate, ovate, entire, acute, unicostate reticulate.

Inflorescence—Racemose, axillary spike.

Flower—Sessile, bracteate, bracteolate, bract and bracteoles large, prominent, leafy and enclose the buds, complete, bisexual, irregular, zygomorphic, pentamerous, cyclic, hypogynous, large, white.

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5 gamopetalous, bilipped ringent, upperor posterior, lip curved, bilobed, lower or anterior lip 3 lobed and covers the upper lip, corolla tube with streaks, white, imbricate, alternate to sepals.

Androecium—Stamens 2, polyandrous, epipetalous, laterally placed at the junction of the upper and the lower lips, filament tough, bent along the margin of the upper lip, hairy at base, anther dithecous, lobes placed on unequal heights, lower lobe spurred, basifixed.

Gynoecium—Bicarpellary, syncarpous, bilocular, carpels placed medianaly or ovary transversely placed, two ovules per locule, placentation axile, ovary superior, placed on a honey disc, style 1, long, hairy, stigma pointed, bifid.

Fruit—Capsule, 4 seeded, seeds supported on jaculators (hook-like).

Floral Formula

Br, %, ♂, ♀, $K_{(5)}$, $C_{(2)(3)}$, $\widehat{A_2}$, $\underline{G_{(2)}}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

Family—Acanthaceae

[1. Plants herbs or shurbs.

2. Leaves opposite decussate.

3. Inflorescence spike, receme or cymose, umbel.

4. Anther lobes situated at unequal heights, lower lobe usually spurred,

5. Ovary bicarpellary, syncarpous, bilocular, axile placentation, 2 to indefinite ovules in each locule, superior ovary, placed on a honey disc.

6. Seeds supported by jaculators.]

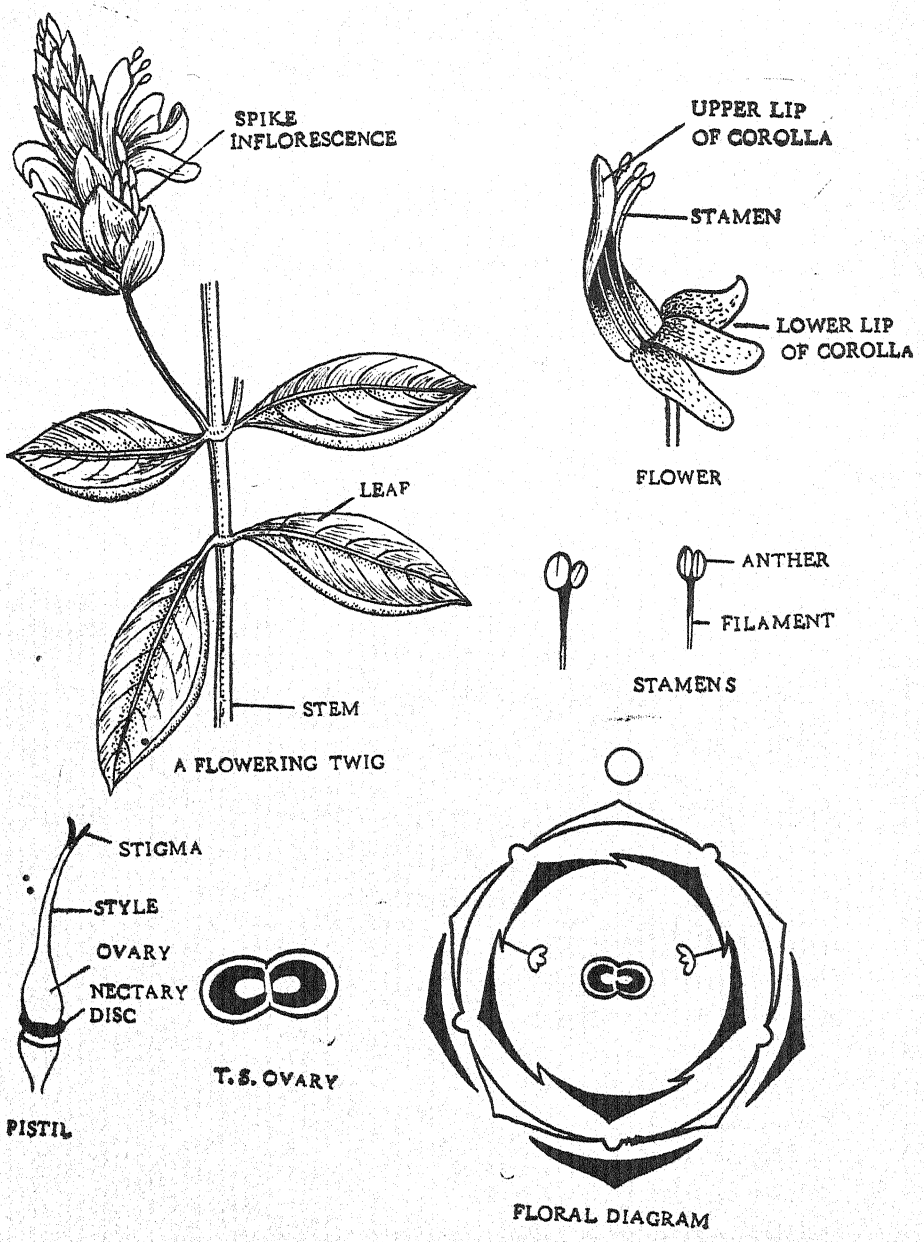


Fig 242. *Adhatoda vasica* (Acanthaceae)

Example 2. *Peristrophe bicalyculata*

(Hindi-Kalmegha or Atrilal)

Habit—A wild annual herb.

Root—Branched taproot.

Stem— Aerial, erect, branched, herbaceous, hexangular, solid, swollen at nodes, hairy, green, slender.

Leaf—Petiolate, cau line, exstipulate, ovate, entire, acute, hairy, unicostate reticulate.

Inflorescence—Cymose, trichotomous.

Flower —Pedicellate, bracteate, bracteolate (5, imbrioate, odd bracteole anterior, one bracteole enlarged), complete, bisexual, zygomorphic, cyclic, hypogynous, small, pink.

Calyx—Se pals 5, polysepalous, odd sepal posterior, alternate to bracteoles, membranous, linear, posterior sepal large, valvate.

Corolla—Petals 5, gamopetalous, bilipped ringent, upper or posterior lip 2 lobed, lower or anterior lip 3 lobed and encloses the upper lip, imbricate, pink.

Androecium—Stamens 2, polyandrous, epipetalous, connective elongated filament long, hairy, anther dithecous, lobes separate, unappendaged.

Gynoecium—Bicarpellary, syucarpous, bilocular, 2 ovules in each locule, axile placentation, ovary superior, honey disc present, style 1, long, hairy, stigma bifid, linear.

Fruit—Capsule.

Floral Formula

$$Br,\ \%,\ \overset{\circlearrowleft}{\underset{+}{\varphi}},\ K_5,\ \overbrace{C(^{2}/_{3})}, A_2, G(\underline{2}).$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

Family—Acanthaceae

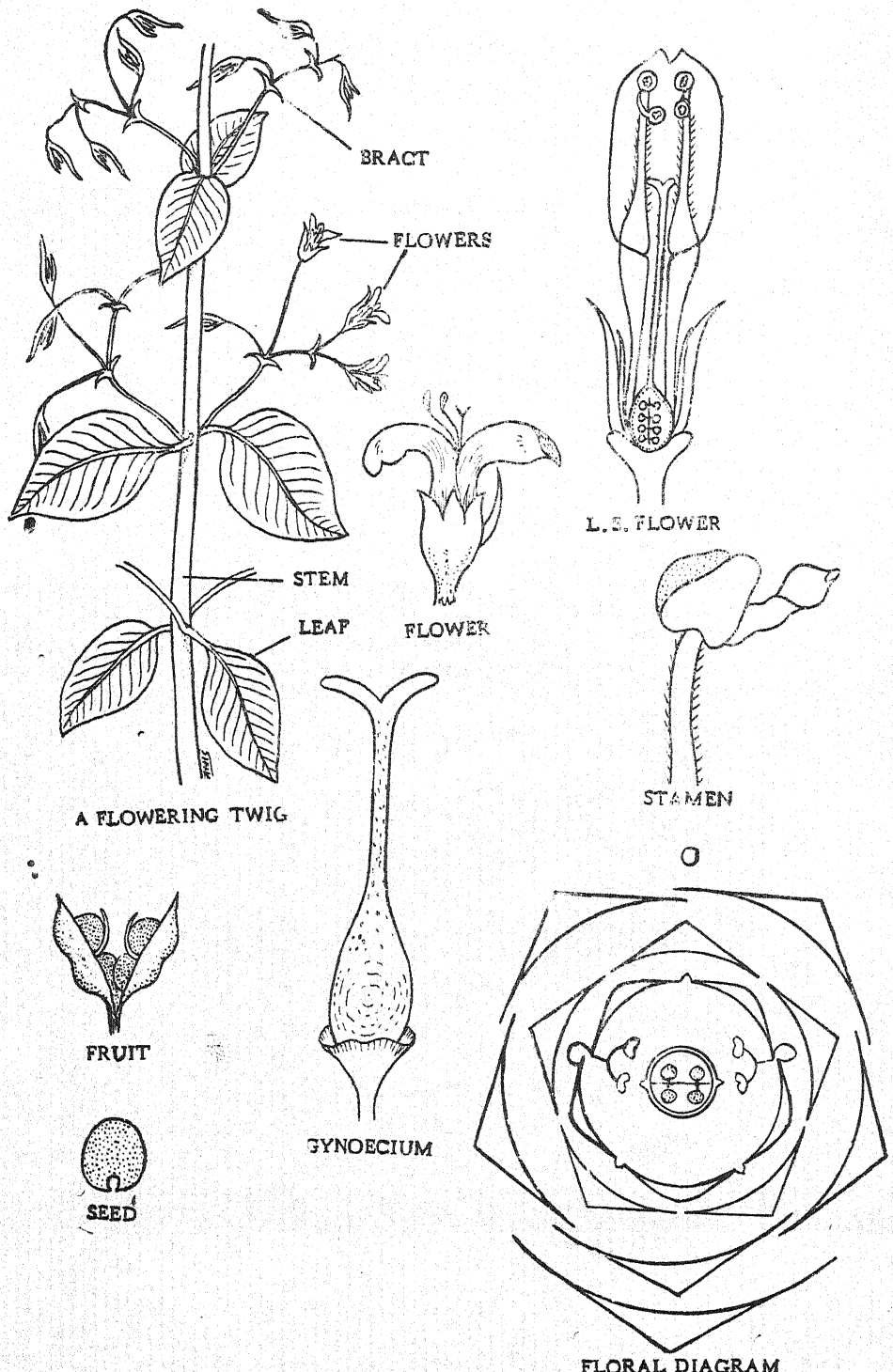


Fig. 243. *Peristrophe bicalyculata* (Acanthaceae)

Example 3. *Barleria prionitis* (Hindi-Koranta).

Habit—A cultivated perennial prickly shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, angular, woody, solid, glabrous, younger part green.

Leaf—Cauline, petiolate, stipulate, stipules modified into spines, inter-petiolar, simple, opposite decussate, lanceolate, entire, acuminate to acute, unicostate reticulate.

Inflorescence—Dichasial cyme (verticillaster).

Flower—Sessile, bracteate, bracteolate, bract 1, large, leafy, bracteoles 6, in two whorls of 3 each, complete, bisexual, zygomorphic, hypogynous, yellow.

Calyx—Sepals 4, polysepalous, in 2 whorls of 2 each, imbricate.

Corolla—Petals 5, gamopetalous, slightly bilipped, imbricate, odd petal anterior, yellow.

Androecium—Stamens 5, polyandrous, epipetalous, out of 5 stamens 2—3 may be staminodes, filament long, anther dithecous, dorsifixed.

Gynoecium—Bicarpellary, syncarpous, bilocular, 2 ovules in each locule, axile placentation, ovary superior, placed on a honey disc, style 1, long, stigma bifid.

Fruit—Capsule.

Floral Formula

$$\text{Br}, \%, \underset{\varphi}{\overset{\sigma}{}}, K_4 \text{ or } 2+2, \widehat{C_{(5)}}, A_5 \text{ or } 2+3, \underline{G}_{(2)}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Personales

Family—Acanthaceae

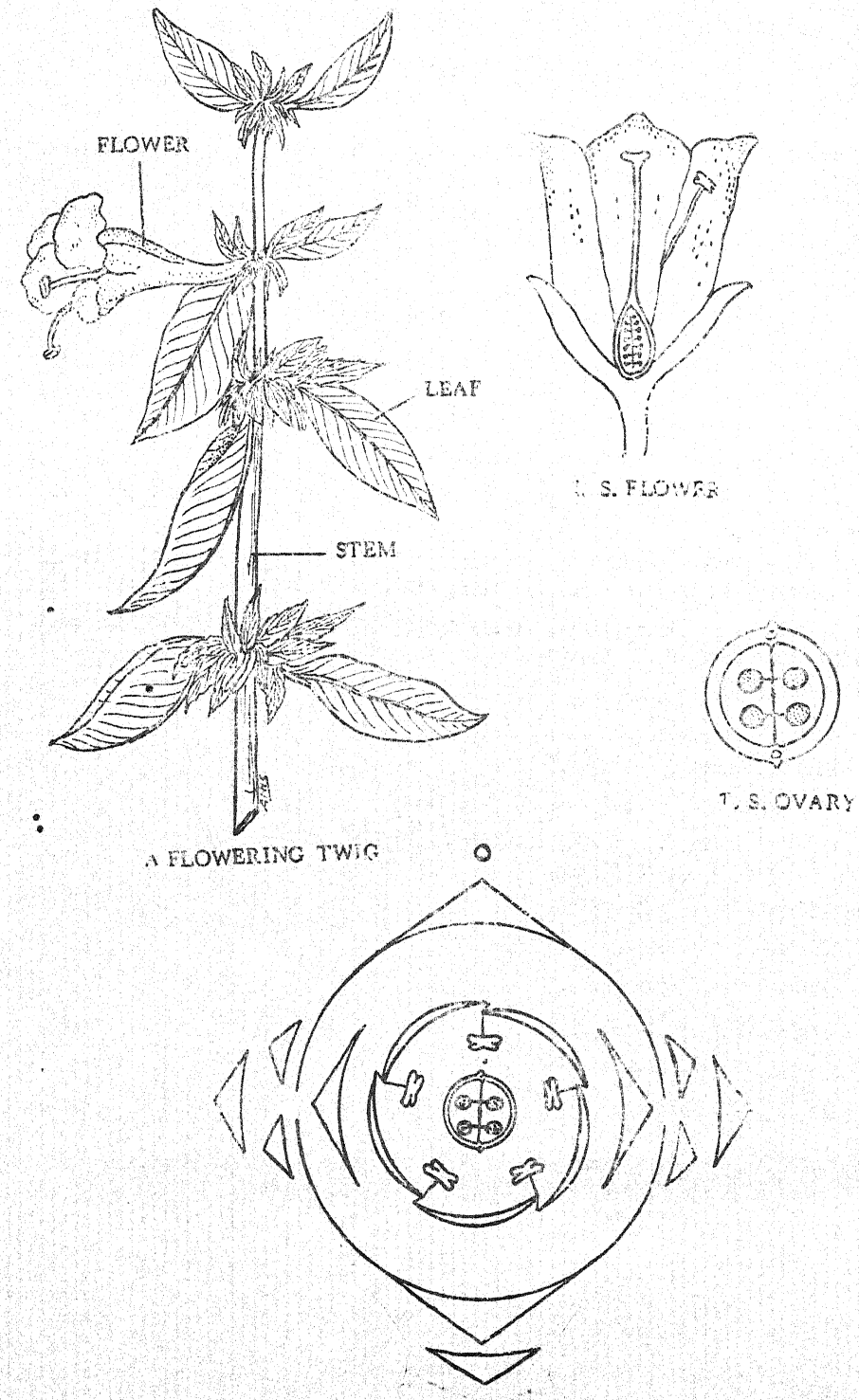


Fig. 244. ***Barleria prionitis*** **(Acanthaceae)**

LABIATAE (LAMIACEAE)

Example 1. Coleus blumei (Coleus : Hindi-Pathorchur)

Habit—A cultivated ornamental annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, squarish or quadrangular, solid, herbaceous, glabrous green.

Leaf—Cauline, petiolate, exstipulate, simple, opposite decussate, ovate, dentate, acute, unicostate reticulate, spotted, varigated pink and violet.

Inflorescence—Verticillaster.

Flower—Pedicellate, pedicel short, bracteate, complete, bisexual, zygomorphic, bilabiate, dark blue, pentamerous, hopogynous.

Calyx—Sepals 5, polysepalous, odd sepal posterior, imbricate.

Corolla—Petals 5, gamopetalous, bilipped, ringent, posterior or upper lip bilobed and anterior or lower lip 3 lobed, imbricate, upper lip encloses the lower lip, blue.

Androecium—Stamens 4, monadephous, epipetalous, 2 long, 2 small, filament long, anther bithecous, versatile, fifth posterior stamen absent.

Gynoecium—Bicarpellary, syncarpous, bilocular, one ovule in each locule, axile placentation, superior ovary, ovary 4 lobed, placed on a honey disc, style 1, long, gynobasic, stigma bifid.

Fruit—Carcerulus.

Floral Formula

$$Br, \%, \overset{\circlearrowleft}{\underset{+}{\varphi}}, K_5, \overset{\frown}{C(^{2}/_{3})}, A_{(4)}, \underline{G_{(2)}}.$$

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

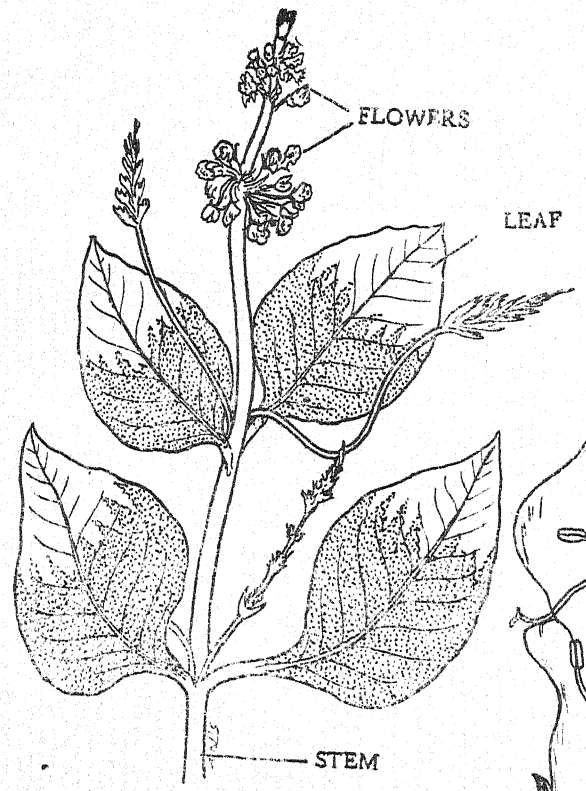
Series—Bicarpellatae

Order—Lamiales

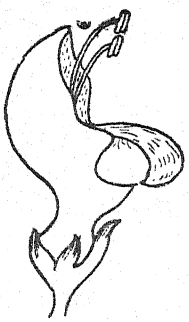
[1. Flowers zygomorphic, corolla bilipped.
2. Stamen 4, didynamous or only 2.
3. Ovary 2—4 locular and fruit drupe or schizocarpic.]

Family—Labiatae (Lamiaceae)

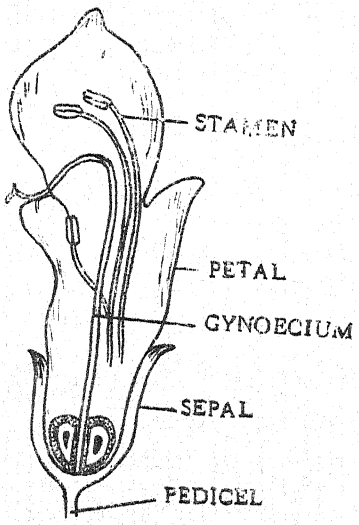
[1. Stem quadrangular, leaf exstipulate, opposite decussate. 2. Inflorescence verticillaster. 3. Ovary bicarpellary, 2—4 locular, 1 or 2 ovules per locule. 4. Style *gynobasic.* 5. Fruit carcerulus.]



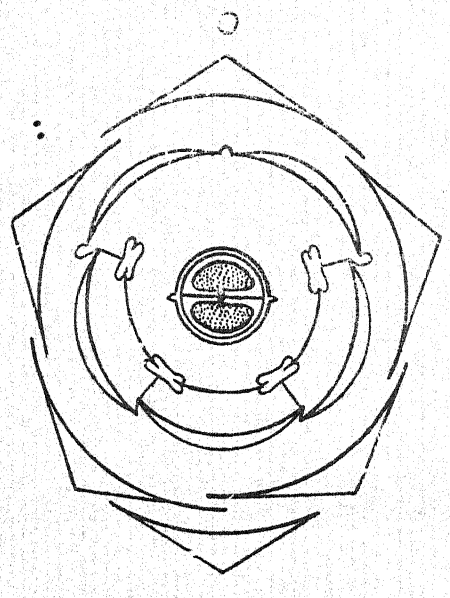
A FLOWERING TWIG



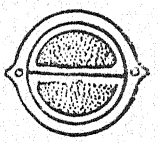
FLOWER



L. S. FLOWER



FLORAL DIAGRAM



T. S. OVARY

Fig. 245. *Coleus blumei* (Labiatae)

Example 2. *Ocimum basilicum* (Basil ; Hindi-Bantulsi)

Habit—A cultivated perennial herb, aromatic.

Root—Branched tap root.

Stem—Aerial, erect, branched, quadrangular, woody, solid, younger stem herbaceous, green or brownish-green, hairy, aromatic.

Leaf—Cauline, simple, petiolate, exstipulate, opposite decussate, whorled below, ovate, serrate, acute, hairy, unicostate reticulate, aromatic.

Inflorescence—Verticillaster.

Flower—Pedicellate, bracteate, bract caducous, complete, bisexual, zygomorphic, bilabiate, cyclic, hypogynous, white, aromatic.

Calyx—Sepals 5, gamosepalous, bilipped, $(^1/_4)$, imbricate, hairy, odd sepals posterior.

Corolla—Petals 5, gamopetalous, alternate to sepals, bilipped, $(^4/_1)$, imbricate, white.

Androecium—Stamens 4, polyandrous, epipetalous, didynamous, fifth posterior stamen absent, filaments of two lateral (posterior) stamens with bearded appendages at base, anther dithecous, basifixed.

Gynoecium—Bicarpellary, syncarpous, tetralocular, one ovule in each locule, axile placentation, superior 4 lobed ovary, style 1, long, gynobasic, stigma bifid.

Fruit—Carcerulus.

Floral Formula

Br, %, $\overset{\circlearrowleft}{\underset{+}{\varphi}}$, K $(^1/_4)$, $\widehat{C(^4/_1)}$, A_2+_2, $\underline{G(_2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Gamopetalae

Series—Bicarpellatae

Order—Lamiales

Family—Labiatae (Lamiaceae)

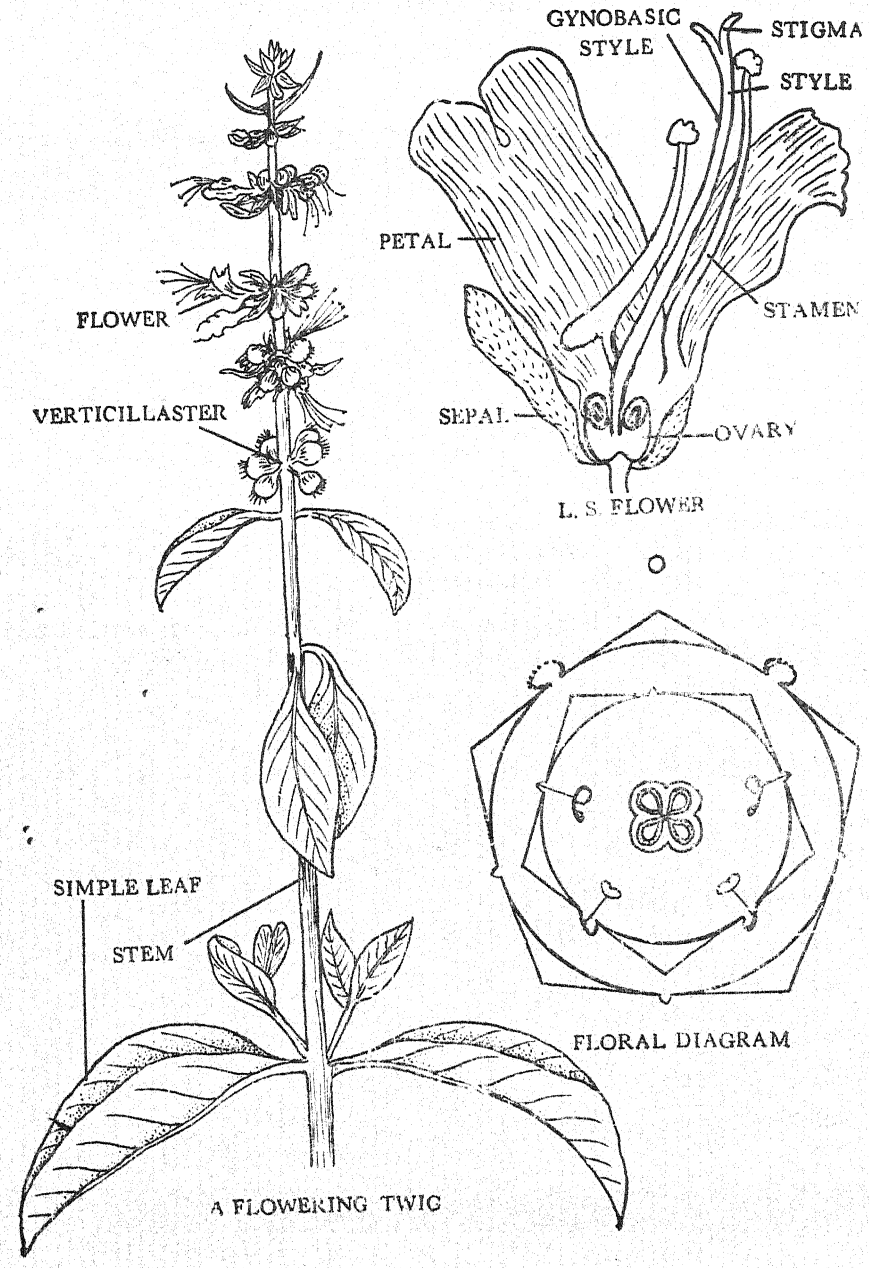


Fig. 246. *Ocimum basilicum* (Labiatae)

AMARANTHACEAE

Example-1. *Amaranthus blitum* (Hindi-Chauli)

Pabit—An annual herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, angular, solid, smooth, green.

Leaf—Cauline, petiolate, exstipulate, simple, alternate, elliptic-ovate, entire, mucronate, unicostate reticulate.

Inflorescence—Spike, axillary or terminal.

Flowers

Male Flower—Sessile, bracteate, bracteolate, incomplete, unisexual, male (staminate), actinomorphic, cyclic, small.

Perianth—Tepals 5, polyphyllous (polytepalous), odd tepal posterior, imbricate, chaffy, membranous.

Androecium—Stamens 5 (some times 4), polyandrous, opposite tepals, filament long, filiform, anther dithecous, versatile, introrse.

Gynoecium—Absent.

Floral Formula

Br, ⊕, ♂, P_5, A_5 or $_4$, Go.

Female Flower—Sessile, bracteate, bracteolate, incomplete. female (pistillate), cyclic, small, hypogynous.

Perianth—Tepals 2, polytepalous, odd tepal posterior, imbricate, membranous, chaffy.

Androecium—Absent.

Gynoecium—Bicarpellary, syncarpous, unilocular, ovule 1, basal, placentation basal, ovary superior, style short, stigma bifid, hairy.

Fruit—Utricle

Floral Formula

Br, ⊕, ♀, P_5, A_0, $G(\underline{2})$.

Systematic Position

Class—Dicotyledons

Sub-Class—Monochlamydeae

(Perianth in 1 whorl, sepaloid or absent).

Series—Curvembryeae (Embryo curved)

Family—Amaranthaceae

[1. Leaf exstipulate, opposite or alternate. 2. Flowers small, haplochalamydous, actinomorphic, bisexual or unisexual. 3. Tepals 5 or 4, usually sepaloid. 4. Stamens 5 or 1—5, anteposed. 5. Gynoecium 2—3 carpellary, syncarpous, unilocular, ovule 1—many, ovary superior.]

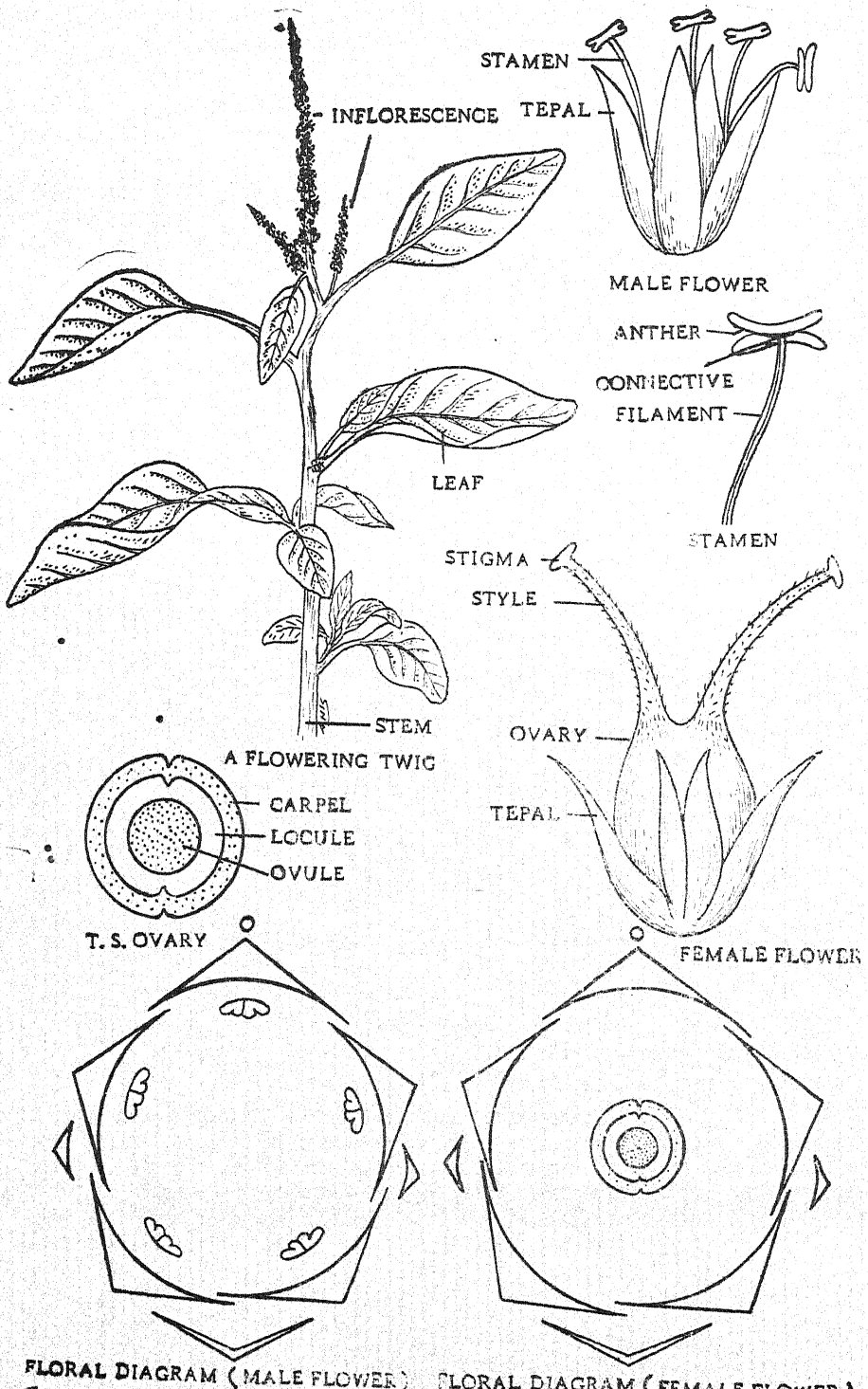


Fig. 247. ***Amaranthus blitum*** **(Amaranthaceae)**

Example 2. *Achyranthes aspera* (Hindi—Latjeera, chirchita).

Habit—A wild annual herb, weed.

Root—Branched tap root.

Stem—Aerial erect, branched, herbaceous, solid, angular, hairy, green.

Leaf—Cauline, sub-sessile, simple, exstipulate, opposite decussate, elliptic-ovate, entire, acute, unicostate reticulate, rough, coriaceous.

Inflorescence—Spike, flowers deflexed.

Flower—Sessile, bracteate, bracteolate, both having spirous tips, complete, bisexual, regular, actinomorphic, pentamerous, hypogynous cyclic, sharply deflexed.

Perianth—Tepals 5, polytepalous, odd tepal posterior, imbricate, membranous, chaffy.

Androecium—Stamens 10, in 2 whorls of 5 each 5 stamens reduced to staminodes, fimbriate, monadelphous, filament thin, anther dithecous, versatile, introrse.

Gynoecium—Bicarpellary, syncarpous, unilocular ovule 1, basal, placentation basal, ovary superior, style short, stigma capitate.

Fruit—Utricle.

Floral Formula

Br, $\oplus$, $\overset{+}{\circlearrowleft}$, P_5, $A_{(5+5)}$, $G_{(2)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Curvembryeae

Family—Amaranthaceae

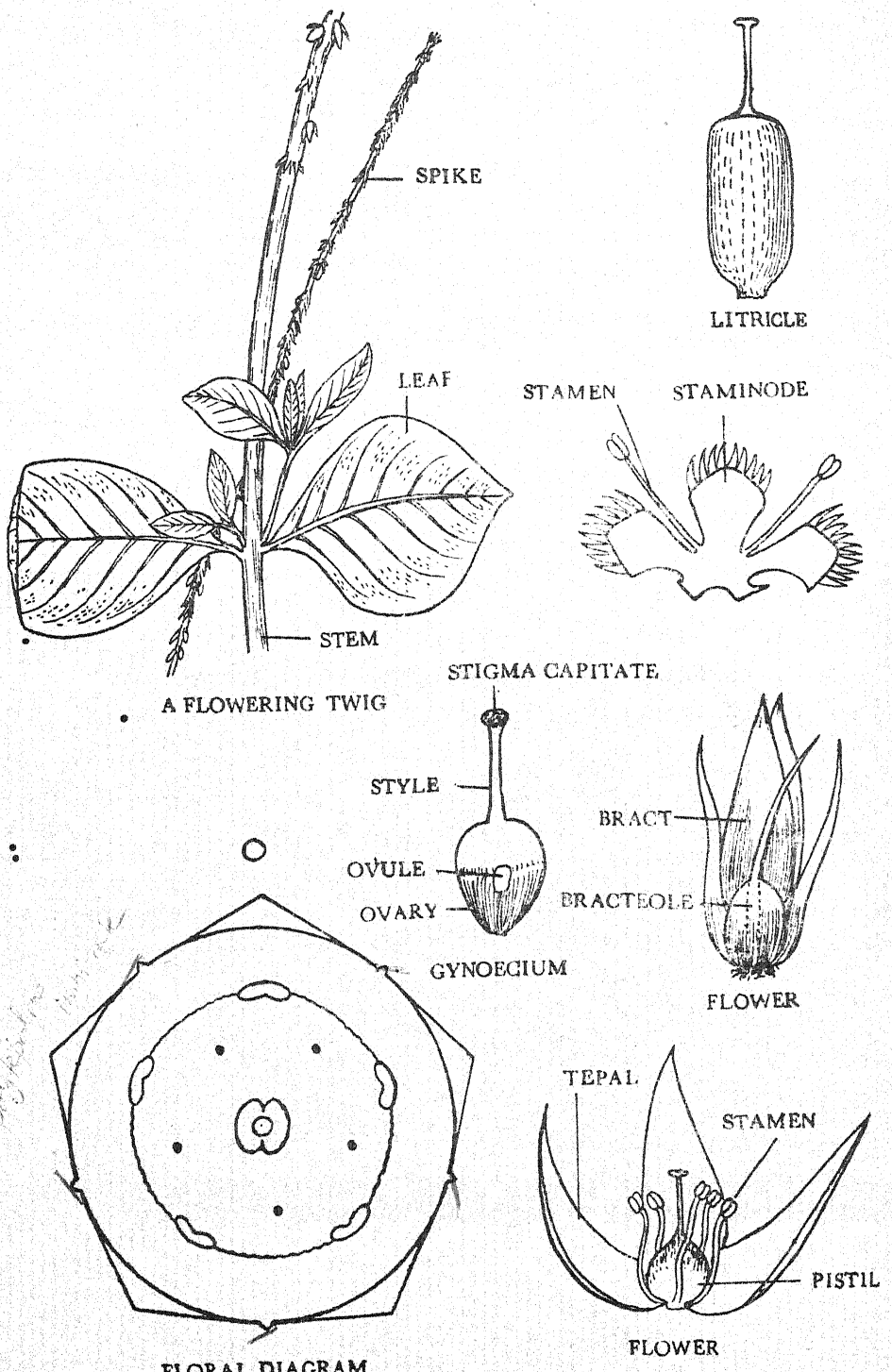


Fig. 248. *Achyranthes aspera* (Amaranthaceae)

POLYGONACEAE

Example 1. *Rumex dentatus* (Hindi—Khatpalak).

Habit—Annual wild herb.

Root—Branched tap root.

Stem—Aerial, erect, branched, herbaceous, angular, solid, glabrous, green.

Leaf—Cauline, petiolate, stipulate, petiole filiform and stipules ochreate, simple, alternate, elliptic-lanceolate, glabrous, undulate, dentate, acute, unicostate reticulate.

Inflorescence—Racemose, panicled clusters.

Flower—Pedicellate, ebracteate, complete, bisexual, regular, actinomorphic, trimerous, cyclic, hypogynous.

Perianth—Tepals 5, in 2 whorls of three each, polytepalous, each whorl valvate, sepaloid members of inner whorl large and cover the fruit.

Androecium—Stamens 6, in 2 whorls of 3 each, polyandrous, stamens of outer whorl alternate to tepals of the inner whorl but stamens of inner whorls are opposite to tepals of inner whorl and alternate to tepals of outer whorl, filaments long, anther dithecous, basifixed, introrse.

Gynoecium—Tricarpellary, syncarpous, unilocular, ovule 1, basal, placentation basal, ovary superior, style short, stigma 3, hanging downward.

Fruit—Nut.

Floral Formula

$\oplus$, σ, P_{3+3}, A_{3+3}, $G_{(3)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Curvembryeae

Family—Polygonaceae

[1. Leaves with ochreate stipules.

2. Flowers bisexual, actinomorphic and haplo to heterochlamydous.

3. Ovary unilocular, ovule 1, basal, superior ovary].

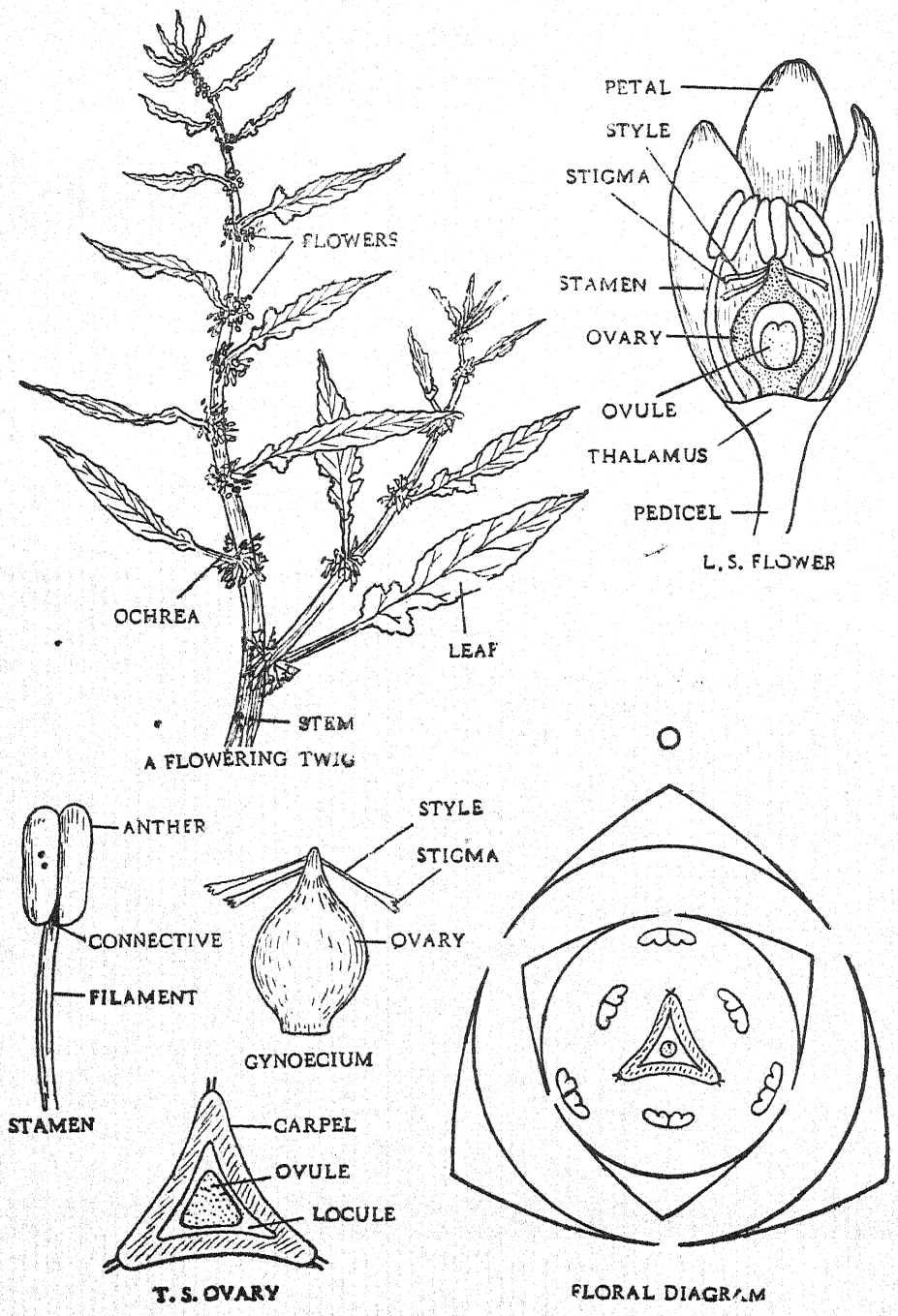


Fig. 249. *Rumex dentatus* (Polygonaceae)

LORANTHACEAE

Example 1. *Loranthus longiflorus* (Hindi—Banda)

Habit—A large bushy usually glabrous branch-parasite (semiparasitic).

Root—Parasitic, branched, branches within the host tissue. Outgrowths are formed on the host where the parasitic roots meet and enter the host.

Stem—Aerial, erect, branched, bark grey, smooth.

Leaf—Petiolate, petiole short, exstipulate, simple, opposite decussate, long, variable in shape, ovate-elliptic or linear-oblong, entire, obtuse, mid rib prominent, usually red, glabrous, thickly coriaceous, unicostate, reticulate.

Inflorescence—Axillary or supra-axillary unilateral raceme, often two in an axil.

Flower—Pedicellate, pedical short, bracteate, bract broadly ovate, concave, sub-acute, complete, bisexual, actinomorphic, epigynous, red or orange.

Calyx—Sepals 5, gamosepalous, tubular, red, odd sepal posterior, valvate, petaloid, persistent, cup shaped, black when ripe.

Corolla—Petals 5, polypetalous, fused at base, petals lie opposite to sepals, valvate, red or orange, long, reflexed.

[Note : The calyx is called as *calyculus* and corolla as *perianth.*]

Androecium—Stamens 5, opposite petals or perianth leaves (tepals), epiphyllous (stamens more or less united with tepals), filament short, anther dithecous or monothecous due to fusion, basifixed, introrse.

Gynoecium—Tricarpellary, syncarpous, unilocular, basal placentation, ovule 1, basal, ovary inferior, style 1, long, stigma prominent, capitate.

Fruit—Pseudocarp (ovary fused with receptacle to form a berry-like fruit which is comparable to apple).

Floral Formula

$$\text{Br},\ \oplus,\ \mathcal{Q}^{\mathcal{J}},\ K_{(5)},\ C_5 \text{ or } P_5,\ \overbrace{A_5},\ G(\underline{3}).$$

Systematic Position

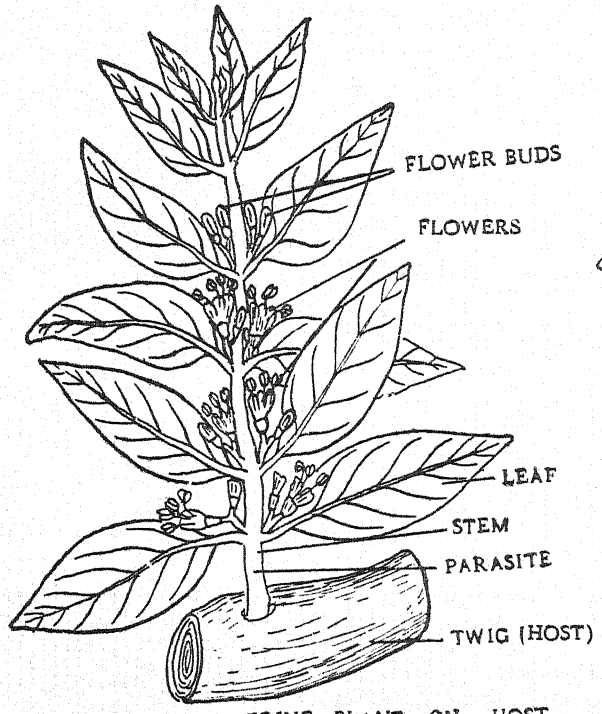
Class—Dicotyledons

Sub-Class—Monochlamydeae

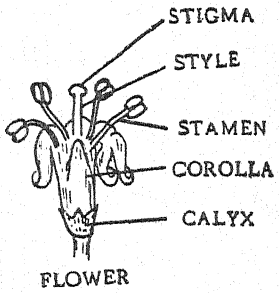
Series—Achlamydosporeae (ovary unilocular, ovules 1—3, poorly developed, seeds endospermous no testa, corolla present).

Family—Loranthaceae

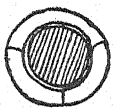
(1) Plants evergreen parasitic shrubs.
(2) Leaves opposite, exstipulate, entire and coriaceous.
(3) Flowers unisexual or bisexual.
(4) Inflorescence in racemes, spike heads or fascicles.
(5) Bract scale-like, bracteoles 2.
(6) Perianth simple or double.
(7) Sepals (calyculus) adnate to ovary, cupular.
(8) Petals or perianth 3—6 or only 2, free or connate.
(9) Stamens as many as corolla lobes or tepals and lie opposite to petals or tepals.
(10) Gynoecium bicarpellary, syncarpous, unilocular, basal placentation, ovule 1, basal, epigynous inferior ovary.
(11) Fruit pseudocarp or berry-like.



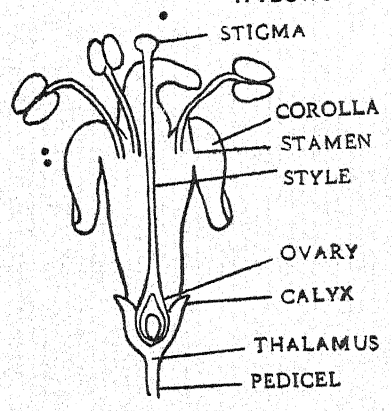
A FLOWERING PLANT ON HOST



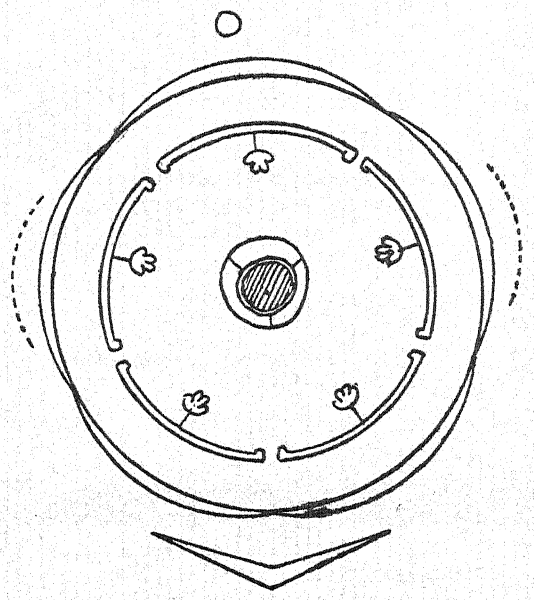
FLOWER



T. S. OVARY



L. S. FLOWER



FLORAL DIAGRAM

Fig. 250. *Loranthus longiflorus* (Loranthaceae)

EUPHORBIACEAE

Example 1. *Euphorbia pulcherrima* Syn. *Poinsettia pulcherrima* (Hindi—Lalpatti)

Habit—A cultivated ornamental perennial shrub.

Root—Branched tap root.

Stem—Aerial, erect, branched, cylindrical, glabrous, younger part herbaceous, woody, solid, milky latex present.

Leaf—Cauline, petiolate, petiole long and hairy, simple, alternate, stipulate, ovate to lobed, entire, acute, unicostate reticulate venation.

Inflorescence—Cyathium arranged in peduncled cymes and each cyathium has one posterior yellowish nectary gland. Cyathium is formed due to fusion of bracts which become cup-like. Inside there is a single female flower surrounded by a number of male flowers. Some bracts are red coloured, showy and large leaf-like.

Male Flower—It is highly reduced and is represented by a single stamen present on a stalk or pedicel, filament long, slender, anther dithecous, basifixed, introrse, male flower bracteate, bract scaly.

Floral Formula

$$Br,\ \overset{\circ}{\underset{+}{\sigma}},\ K_0,\ C_0,\ A_1,\ G_0$$

Female Flower—There is only one female flower, it is highly reduced, represented by a gynoecium, placed on a stalk or pedicel, ovary tricarpellary syncarpous, trilocular, superior, axile placentation, one ovule in each locule, style short, stigma 3, each bifid.

Fruit—Capsule.

Floral Formula

$$Br,\ \varphi,\ K_0,\ C_0,\ A_0,\ \underline{G(_3)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Unisexuales (flowers unisexual, perianth sepaloid, reduced or absent)

Family—Euphorbiaceae

[1. Plants mainly shrubs or trees or a few herbs. 2. Latex present. 3. Leaves alternate and stipulate. 4. Inflorescence cyathium or variable. 5. Flowers regular unisexual, hypogynous, perianth 1 or 2 whorled, or reduced, pentamerous. 6. Stamens 1—∞, free or connate. 7. Ovary tricarpellary, syncarpous, trilocular, axile placentation, stigma bifid. 8. Fruit schizocarpic, regma, capsule, drupe or berry.]

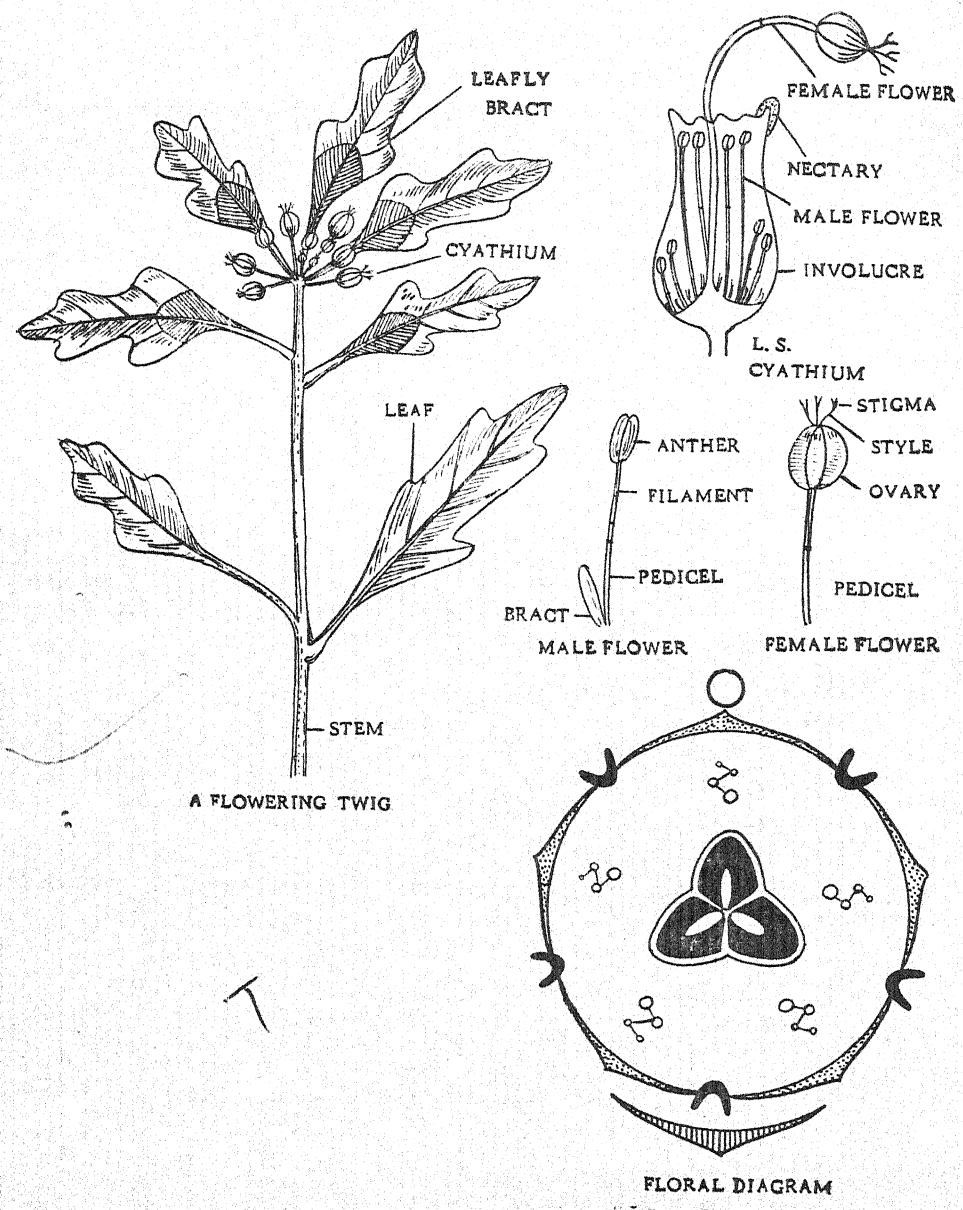


Fig. 251. *Euphorbia pulcherrima* (Euphorbiaceae)

Example 2. *Croton bonplandianum*

Habit—A perennial herb or undershrub.

Root—Branched, tap root.

Stem—Aerial, erect, branched, angular, ribbed, herbaceous above, woody below, soid, green or browish green, hairs stellate, watery latex present.

Leaf—Petiolate, cauline, exstipulate, simple, alternate below, opposite above, lanceolate, serrate or serrulate, acute to acuminate, unicostate reticulate venation, petiole hairy, hairs stellate, watery latex present.

Inflorescence—Racemose, male flowers above, usually in clusters, female flowers solitary, below.

Flower—Pedicellate, pedicel short (sub-sessile) bracteate, unisexual, incomplete, cyclic, actinomorphic, female flower hypogynous, intrastaminal disc of 5 minute glands present opposite sepals.

Male Flower

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Petals 5, polypetalous, valvate, white, alternate to sepals.

Androecium—Stamens numerous, in many series, filaments connate below, anthers adnate, dithecous, dehiscence lateral, 5 minute bright red intrastaminal nectary glands present alternating to petals.

Female Flower

Calyx—Sepals 5, gamosepalous, odd sepal posterior, valvate.

Corolla—Absent.

Androecium—Absent.

Gynoecium—Tricarpellary, syncarpous, trilocular, axile placentation, one ovule in each locule, ovary superior, ovary wall hairy, hairs stellate, style 3, stigma bifid, 6, tip knob-like, 5 minute bright red glands present opposite sepals.

Fruit—Capsule.

Floral Formula

Male Flower

Br, ⊕, ♂, $K_{(5)}$, C_5, $A\infty$, G_0

Female Flower

Br, ⊕, ♀, K_5, C_0, A_0, $G_{(3)}$.

Systematic Position.

Class—Dicotyladons

Sub-class—Monochlamydeae

Series—Unisexuales

Family—Euphorbiaceae

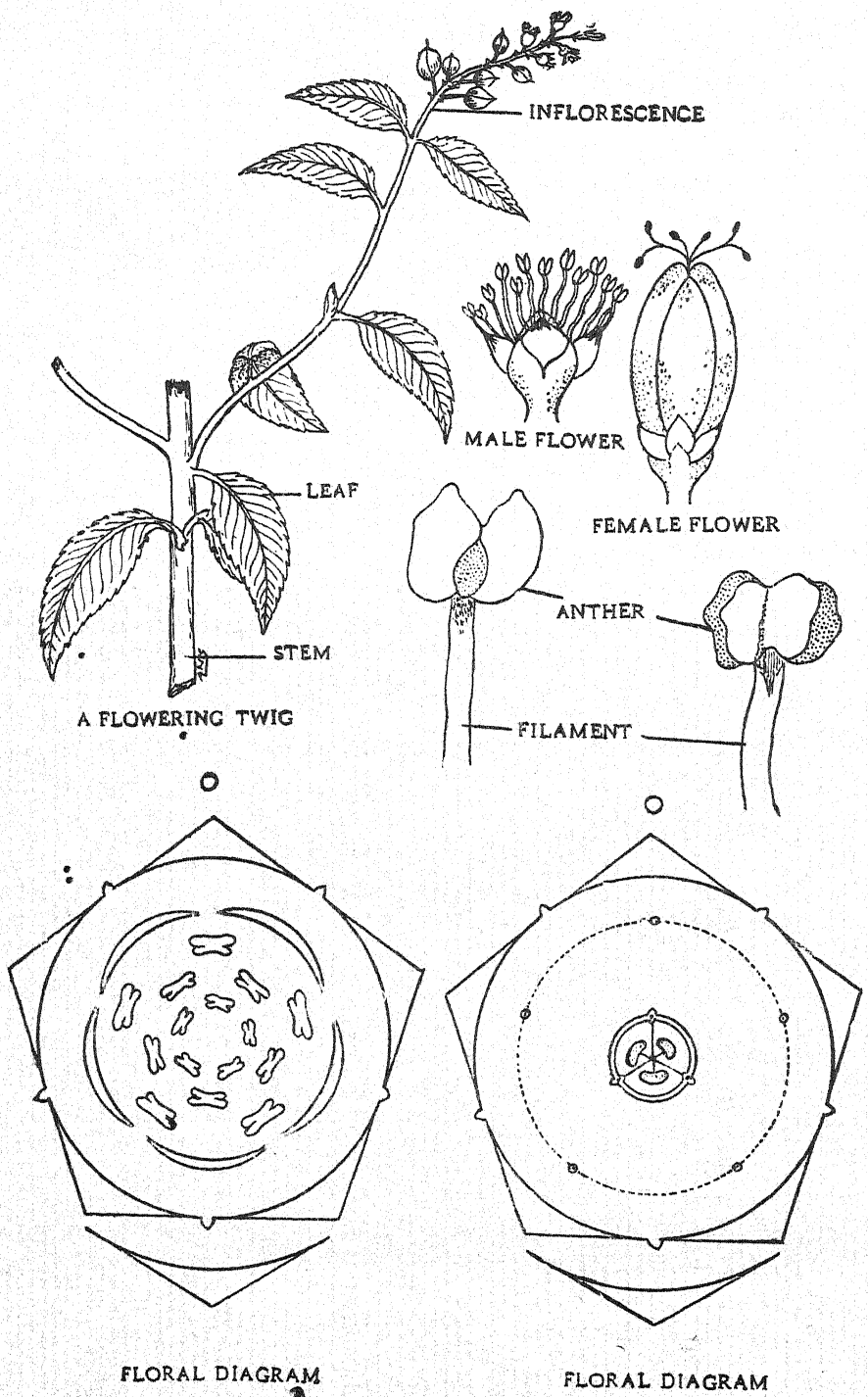


Fig. 252. *Croton bonplandianum* (Euphorbiaceae)

Example 3. *Euphorbia splendens* Syn. *E. milii* (Crown of thorns or garden dodak)

Habit—A cultivated, ornamental prickly under shrub with milky latex.

Root—Branched tap root.

Stem—Aerial, erect, branched, milky latex present, woody, angular with numerous long or short thorns (prickles).

Leaf—Petiolate, petiole short, cauline, exstipulate, simple, alternate, spathulate, elliptic-lanceolate, entire, mucronate, unicostate reticulate venation, latex present.

Inflorescence—Cyathium, arranged in dichotomous cymes ; cyathia large with scarlet bracts forming involucre with 5 glands.

Flowers—Pedicellate, bracteate, highly reduced, male flower represented by a single stamen, a number of male flowers surround the female flower which is represented by a single gynoecium, flowers incomplete, unisexual, naked, female flowers hypogynous.

Male Flower

Calyx—Absent

Corolla—Absent

Androecium—Stamen 1, present on a pedicel or stalk, filament stout, anther dithecous, basifixed.

Gynoecium—Absent

Female Flower

Calyx—Absent

Corolla—Absent

Androecium—Absent

Gynocium—Tricarpellary, syncarpous, trilocular, one ovule in each locule, axile placentation, superior ovary, placed on a stalk or pedicel, style 3, stigma 6, each linear with knob-like tip.

Fruit—Capsule.

Floral Formula

Male Flower

Br, ♂, K_0, C_0, A_1, G_0.

Female Flower

Br, ♀, K_0, C_0, A_0, $\underline{G_{(3)}}$.

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Unisexuales

Family—Euphorbiaceae

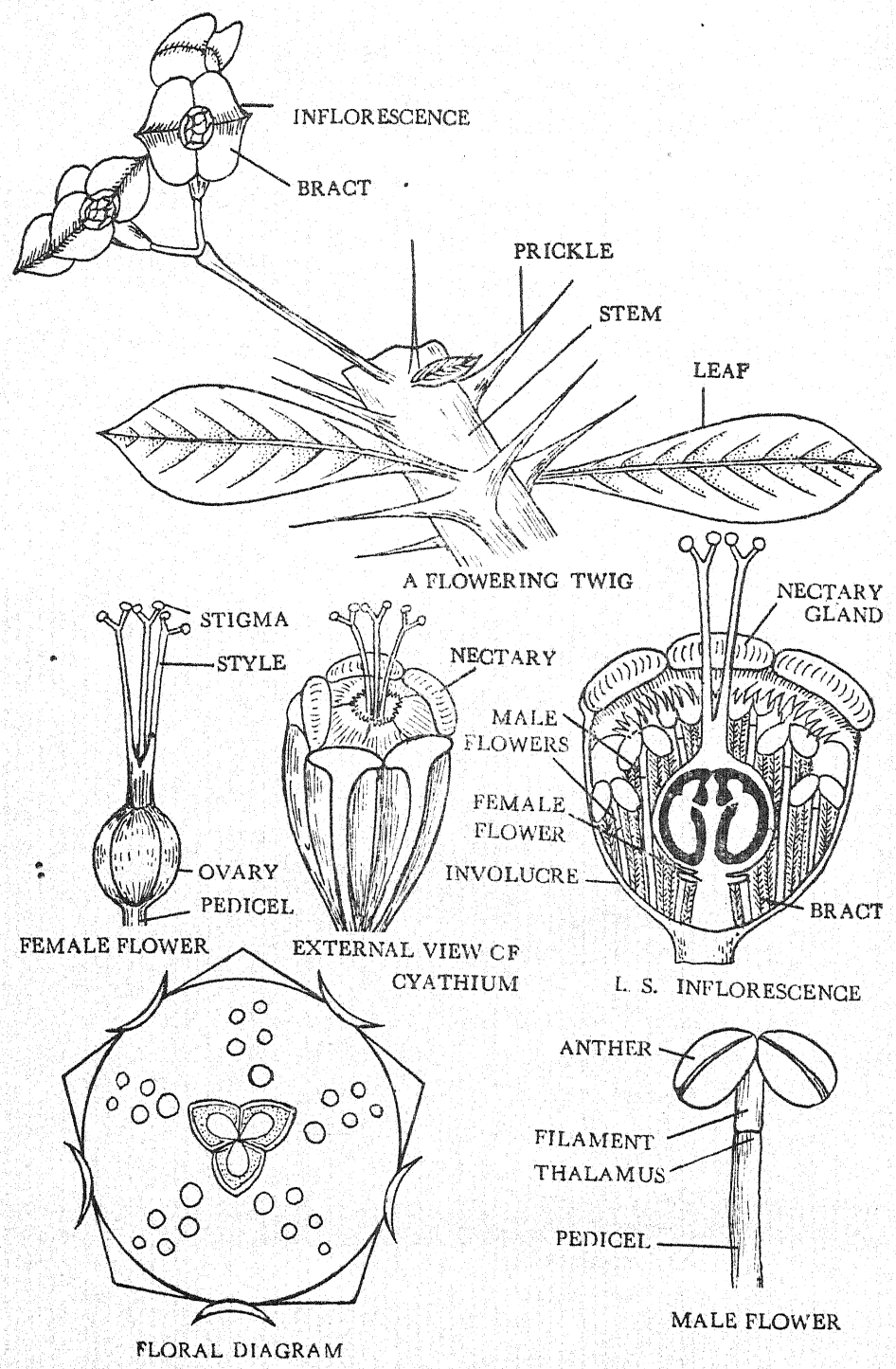


Fig. 253. ***Euphorbia splendens*** **Syn.** ***E.-milii*** **(Euphorbiaceae)**

Example 4. *Euphorbia hirta* (Hindi—Dudhi)

Habit—A small annual wild herb.

Root—Branched tap root.

Stem—Aerial, erect, unbranched, some times branched, solid, milky latex present, herbaceous, green or brownish green, hairy, hairs brown, dense.

Leaf—Cauline, petiolate, petiole short or sub-sessile, stipulate, stipules caducous, simple, opposite superposed, oblong-lanceolate, serrulate, acute, unicostate reticulate venation, latex present.

Inflorescence—Cyathium, cyathia arranged in peduncled axillary cymose manner.

Flower—Pedicellate, bracteate, incomlete, unisexual, female flower is naked and is represented by a single gynoecium and is surrounded by a number of male flowers. Each male flower is naked and is represented by a single stamen. Both male and female flowers are present on pedicels or stalks. Female and male flowers are surrounded by a common involucre of bracts with 4 or 5 honey glands.

Male Flower

Calyx—Absent.

Corolla—Absent.

Androecium—Stamen 1, stalked or pedicellate, filament slender, anther dithecous, basifixed.

Floral Formula

Br, ♂, K_0, C_0, A_1, G_0.

Female Flower

Calyx—Absent.

Corolla—Absent.

Androecium—Absent.

Gynoecium—Single, stalked, tricarpellary, syncarpous, trilocular, axile placentation, one ovule in each locule, superior ovary (hypogynous), style 3, stigma 3, each bifid.

Fruit—Capsule.

Floral Formula

Br, ♀, K_0, C_0, A_0, $\underline{G_{(3)}}$.

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Unisexuales

Family—Euphorbiaceae

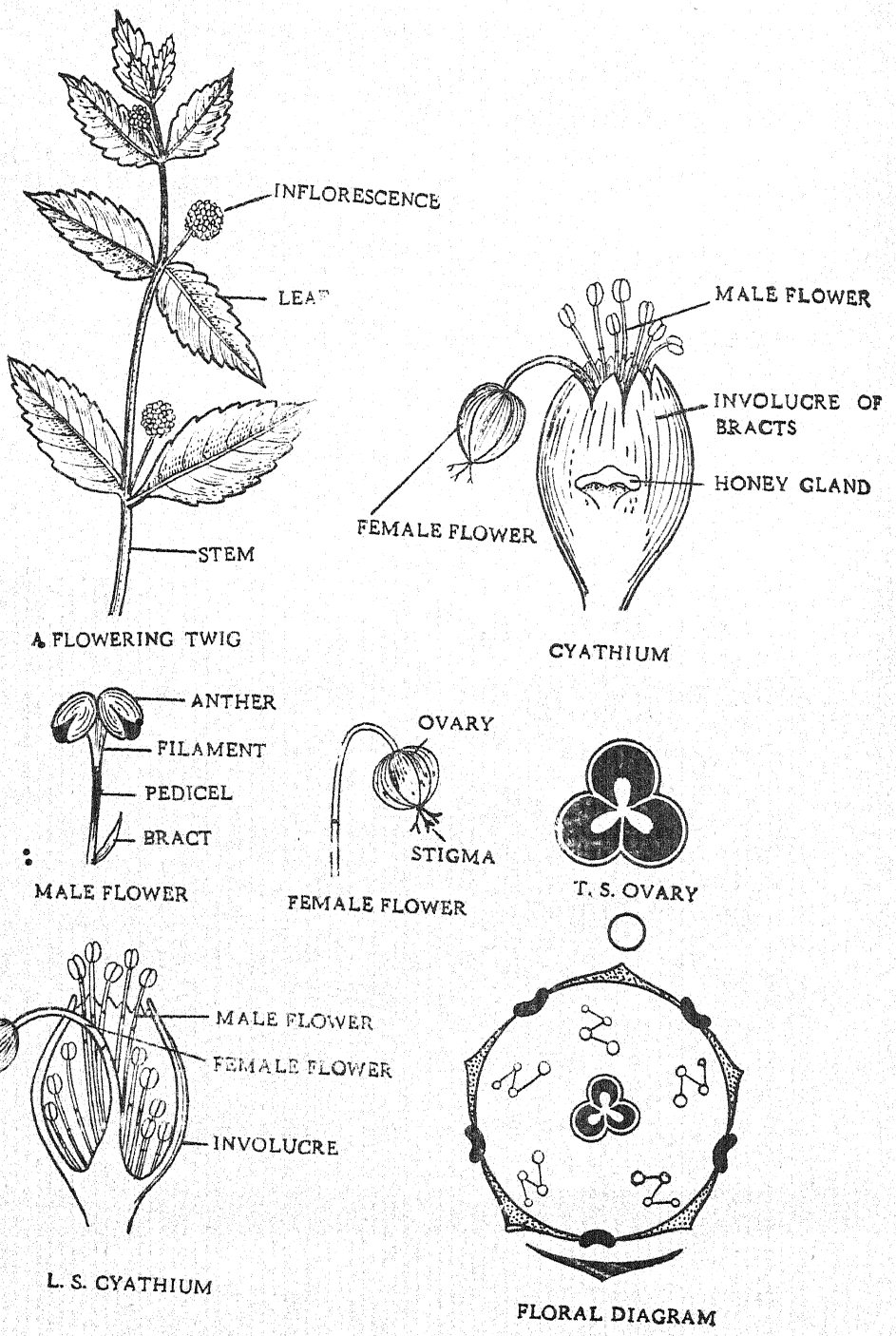


Fig. 254. ***Euphorbia hirta*** **(Euphorbiaceae)**

Example 5. *Euphorbia microphylla* (Hindi—Choti dudhi)

Habit—An annual herb.

Root—Branched tap root.

Stem—Aerial, prostrate, branched, herbaceous, glabrous, spreading, latex present.

Leaf—Cauline, subsessile, simple, stipulate, opposite, small, obliquel-oblong to rounded oblong or sub-quadrate, entire, retuse, truncate or rouny ded and more or less toothed.

Inflorescence—Cyathium.

Flower—Pedicellate, bracteate, incomplete, unisexual, involucre o, bracts fuse and form cup-like structure (cyathium with 5 honey glandsf female flower represented by a single gynoecium and is surrounded by a number of male flowers, male flower represented by a single stamen.

Male Flower

Calyx—Absent.

Corolla—Absent.

Androecium—Stamen 1, pedicellate, bracteate, filament long, anther dithecous, basifixed.

Gynoecium—Absent.

Floral Formula

Br, ♂, K_0, C_0, A_1, G_0.

Female Flower

Calyx—Absent.

Corolla—Absent.

Androecium—Absent.

Gynoecium—Tricarpellary, syncarpous, trilocular, axile placentation, one ovule in each locule, superior hypogynous ovary, style 3, short, stigma 3, each bifid.

Fruit—Capsule

Floral Formula

Br, ♀, K_0, C_0, A_0, $G_{(3)}$.

Systematic Position

Class—Dicotyledons

Sub-class—Monochlamydeae

Series—Unisexuales

Family—Euphorbiaceae

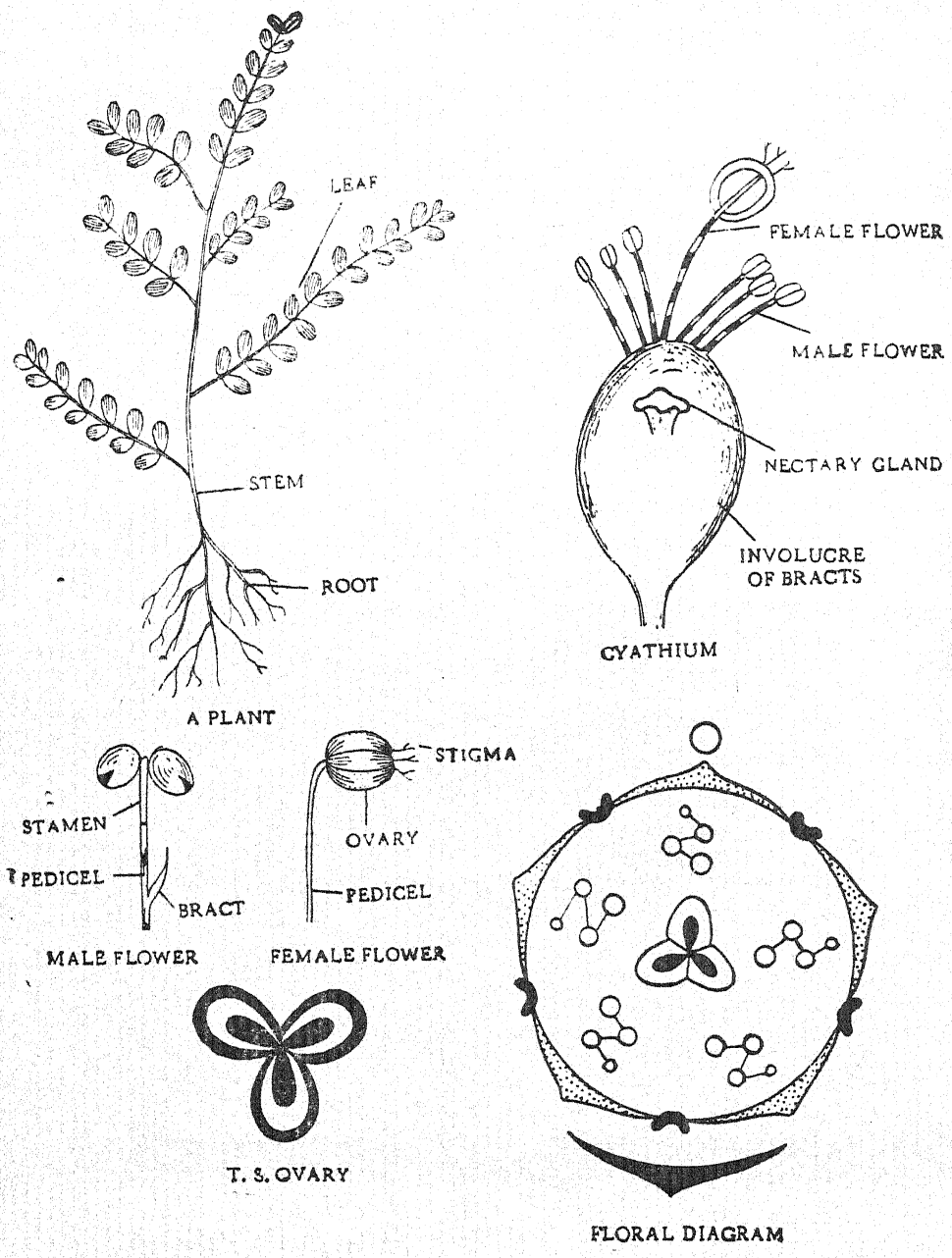


Fig. 255. *Euphorbia microphylla* (Euphorbiaceae)

MORACEAE (URTICACEAE)

Example 1. *Morus alba* (Mulberry : Hindi-Shahtoot)

Habit—A small cultivated tree.

Root—Tap root, branched.

Stem—Aerial, erect, branched, woody, solid, cylindrical, upper portions herbaceous, smooth, green, milky latex present.

Leaf—Cauline, petiolate, stipulate, simple, palmately lobed, dentate, acute, pubescent, multicostate reticulate venation, milky latex present.

Inflorescence—Catkin.

Flower—Sessile, ebracteate, incomplete, unisexual, actinomorphic, embedded within the receptacle, male flowers tetramerous and cyclic, female flowers tetramerous, cyclic, hypogynous.

Male Flower

Perianth—Tepals 4, in two whorls of 2 tepal each, polytepalous or polyphyllous, imbricate, ovate, hairy, outer whorl antero—posterior.

Androecium—Stamens 4, polyandrous, in two whorls of 2 each, opposite the tepals, filaments long, exerted, anther dithecous, basifixed, introrse.

Gynoecium—Absent.

Female Flower

Perianth—Tepals 4, in 2 whorls of 2 tepal each, polyphyllous, imbricate, ovate, hairy, outer whorl antero-posterior.

Androecium—Absent.

Gynoecium—Bicarpellary, syncarpous, unilocular superior ovary with one pendulous ovule, style 1, long, stigma bifid, elongated, rough, coiled.

Fruit—Sorosis, with sweet juice.

Floral Formula

Male Flower

$\bar{E}$ br, $\oplus$, ♂, $P_{2}+_{2}$, A_{4}, G_{0}.

Female Flower

$\bar{E}$ br, $\oplus$, ♀, $P_{2}+_{2}$, A_{0}, $\underline{G(_{2})}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Monochlamydeae

Series—Unisexuales

Family—Moraceae

[1. Plants generally shrubs or trees.

2. Milky latex present.

3. Leaves alternate, stipulate, stipules lateral or intrapetiolar, leaves may have cystolith.

4. Inflorescence, generally modified cyme, catkin, hypanthodium.
5. Flowers unisexual, incomplete, actinomorphic, hypogynous.
6. Stamens as many as the tepals, opposite.
7. Ovule single, pendulous, embryo curved.]

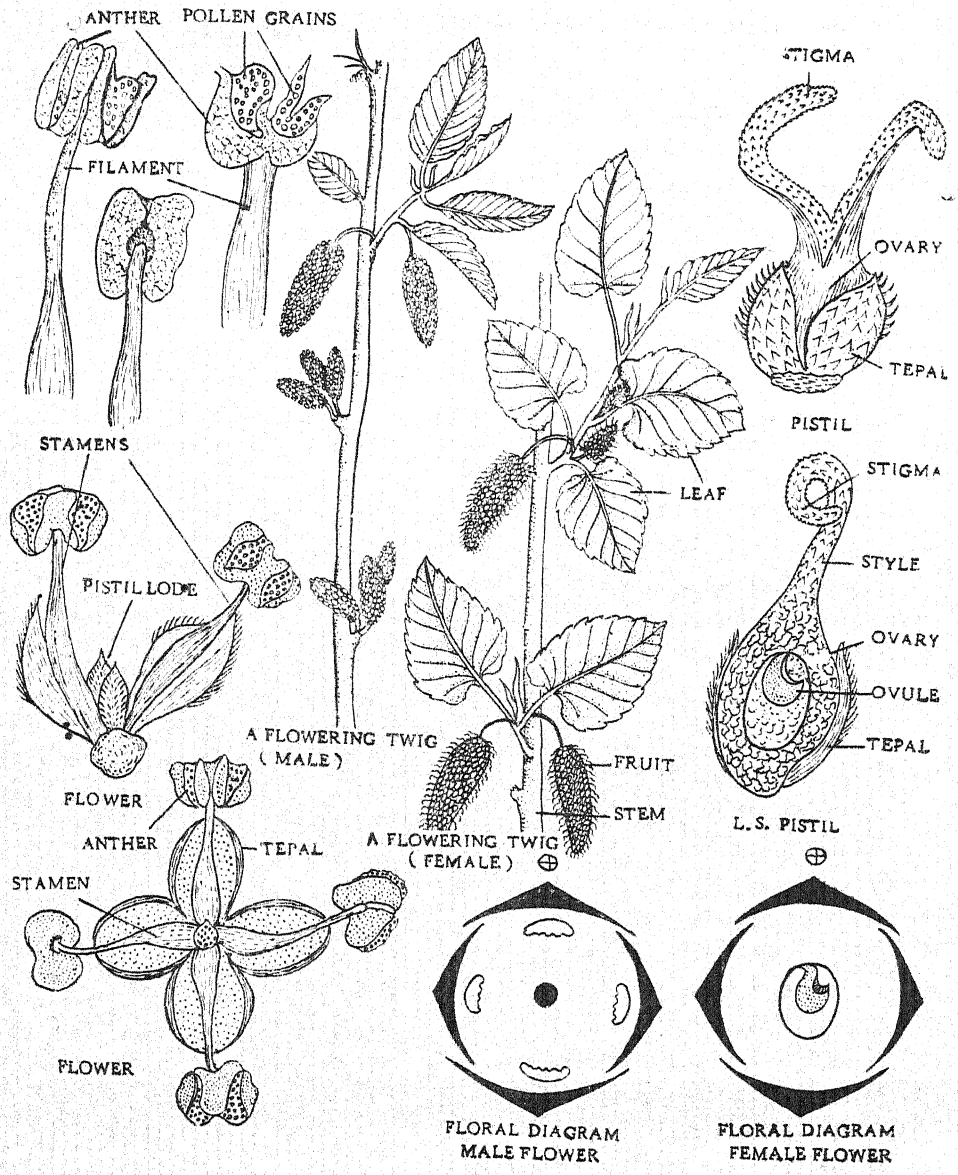


Fig. 256. *Morus alba* (Moraceae)

Example 2. *Ficus glomeratus* (Hindi-Goolar)

Habit—A cultivated tree.

Root—Tap root, branched.

Stem—Aerial, erect, branched, cylindrical, woody, solid, upper portions herbaceous, green, milky latex present.

Leaf—Petiolate, stipulate, stipules envelope young bud, caducous, brownish, leaf simple, alternate, ovate-oblong, entire, acute, glabrous, unicostate reticulate, milky latex present.

Inflorescence—Hypanthodium or syconium, arranged in clusters, each subtended by a whorl of bracts (usually 3), hypanthodium opens at apex by an ostiole.

Flower—Ebracteate, sessile to pedicellate, incomplete, unisexual, regular, actinomorphic, cyclic, interspersed with pink scales, hypogynous (female), light pink, male flowers near the mouth of hypanthodium, sessile, female sub-sessile and all round the wall of receptacle, gall or sterile flowers pistillate, stalked, mixed with female flowers.

Male Flower

Perianth—Tepals 4, polyphyllous, in 2 whorls of 2 each, light pink imbricate, outer whorl antero-posterior, membranous.

Androecium—Stamens 2, polyandrous, opposite outer tepals, antero-posterior, filament curved, flat, anther dithecous, dorsifixed, introrse.

Gynoecium—Absent.

Floral Formula

δ, $\oplus$, P_4, A_2, G_0

Female Flower

Perianth—Tepals 5, gamotepalous, odd tepal posterior, valvate, membranous, light pink.

Androecium—Absent.

Gynoecium—Bicarpellary, syncarpous, unilocular, superior ovary,

Floral Formula

$\oplus$, φ, $P_{(5)}$, A_0 $G_{(\underline{2})}$.

Gall Flowers—Pedicellate, pistillate, sterile, perianth short, style rudimentary & short.

Systematic Position

Class—Dicotyledons

Sub-Class—Monochlamydeae

Series—Unisexuales

Family—Moraceae

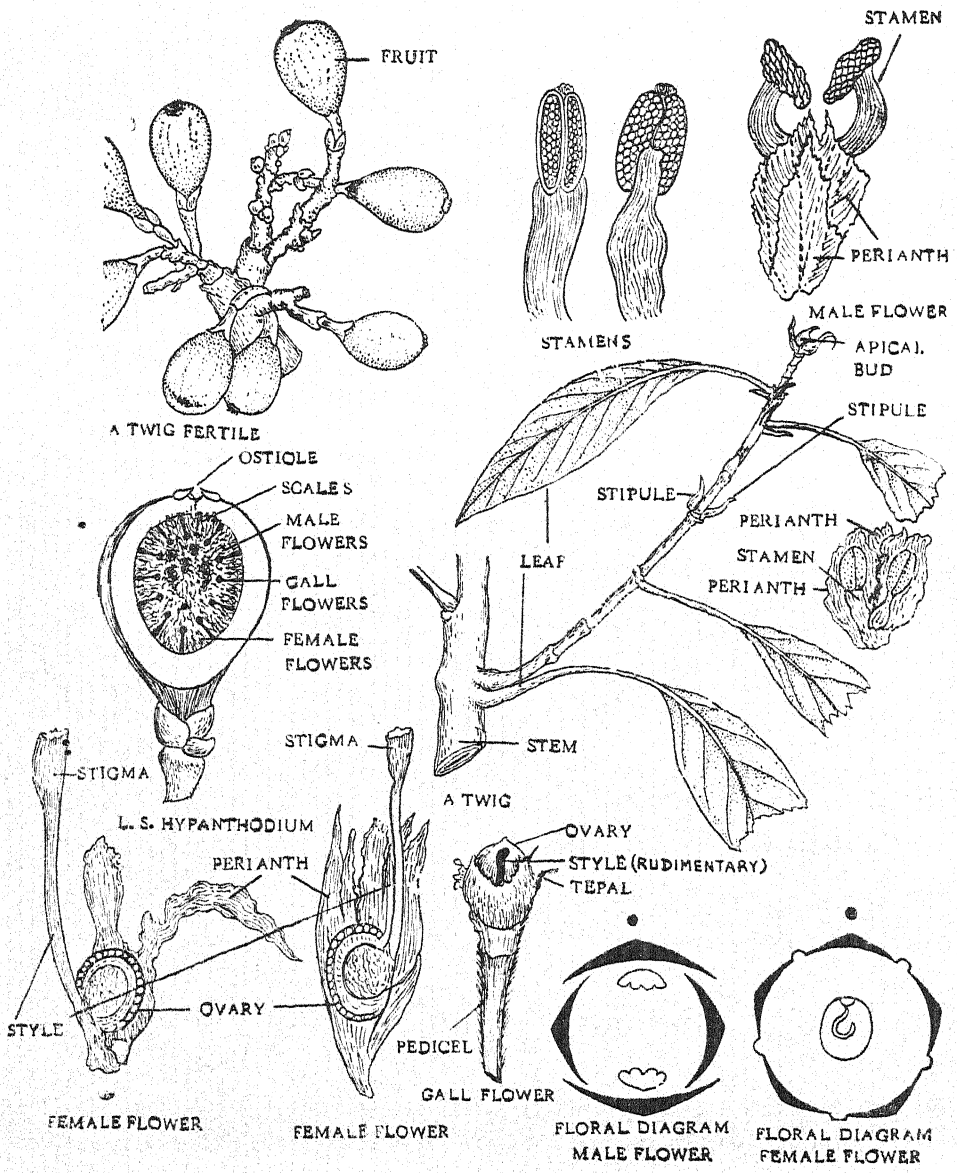


Fig. 257. *Ficus glomeratus* (Moraceae)

Example 3. *Cannabis sativa* (Hemp ; Hindi-Bhang)

Habit—A cultivated annual undershrub, rarely perennial, also wild in moist places.

Root—Tap root, branched.

Stem—Aerial errect, branched, angular, woody, solid, upper portions harbaceous, green.

Leaf—Cauline, simple, alternate, lower opposite, stipulate, stipules, caducous, covering the leaf bud, petiolate, petiole long, lamina deeply lobed upper 1-3, lower 5-11 parts, lobes serrulate, lanceolate, acute, unicostate reticulate, leaf multicostate reticulate.

Inflorescence—Axillary panicled cymes (males), females in axillary racemes.

Flowers—Bracteate, pedicellate, incomplete, unisexual, actinomorphic or zygomorphic, pale yellow, drooping, bracts in female convolute, leafy.

Male Flower

Perianth—Tepals 5, polytepalous, odd tepal posterior, imbricate, sepaloid.

Androecium—Stamens 5, polyandrous, opposite, erect in bud, filament filiform, anther dithecous, oblong, dorsifixed, introrse.

Gynoecium—Absent.

$\%$, δ, P_5, A_5, G_0.

Female Flower

Perianth—Tepal 1, large, hyaline, embracing the base of the ovary.

Androecium—Absent.

Gynoecium—Ovary sessile, bicarpellary (1 fertile and 1 sterile), unilocular, superior, ovule pendulous, reversed, campylotropous, style central, arms 2, filiform, hairy, caducous, stigma 2.

Fruit—A compressed crustaceous *nut*.

Floral Formula

$\oplus$, φ, P_1, A_0, $G_{(2)}$.

Systematic Position

Class—Dicotyledons

Sub-Class—Monochlamydeae

Series—Unisexuales

Family—Moraceae

[Note—This plant is kept in the Cannabinaceae family].

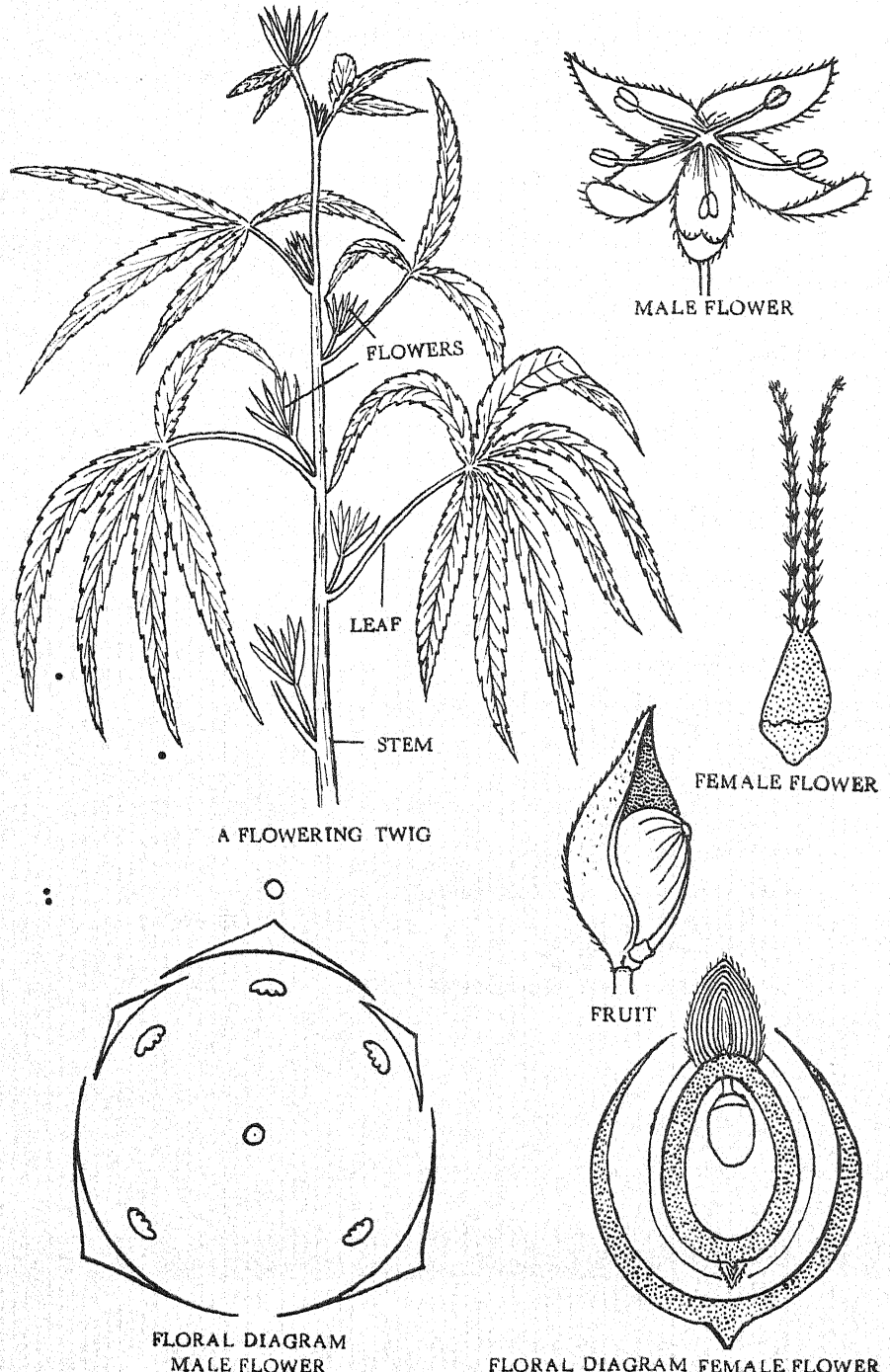


Fig. 258. *Cannabis sativa* (Moraceae)

CASUARINACEAE

Example 1.- *Casuarina equisetifolia* (Hindi-Jhau)

Habit—A cultivated or wild evergreen tree or shrub.

Root—Tap root, branched.

Stem—Aerial, erect, branched, branches arranged in whorls, woody, solid, angular, ribbed, jointed, upper portions green, photosynthetic, hairy, hairs long, protruding, present in the furrows.

Leaf—Cauline, scale like, reduced, non-green, non-photosynthetic, linear, lanceolate, in whorls, sessile, exstipulate, entire, all leaves at the node fuse at base to form a sheath at the node.

Inflorescence—Spike (male flowers looking like catkins) and heads (female flowers) on short lateral branches.

Flowers—Unisexual, incomplete, bracteate, male flowers pedicellate, regular, represented by single stamen arranged in whorls, each in the axil of a bract, bracts fuse forming sheath, female flower sessile, bracteate, hypogynous.

Male Flower

Perianth—Tepals 4, polyphyllous, in two whorls of 2 each, tepals of the inner whorl are smaller in size and antero-posterior, imbricate. The tapals are also referred as bracteoles, then flower is naked.

Androecium—Stamen 1, filament short in bud but later elongates, anther dithecous, basifixed, dehisce by longitudinal slit.

Gynoecium—Absent.

Floral Formula

$\oplus$, ♂, P_2+_2, A_1, G_0.

Female Flower

Perianth—Tepals 2, lateral in position, referred as bracteoles, then flower naked.

Androecium—Absent.

Gynoecium—Bibarpellary, syncarpous, unilocular (due to suppression of posterior locule), parietal placentation, 2 orthrotropous ovules on the placenta, superior ovary, style short, stigma 2, long.

Fruit—One seeded small winged samara.

Floral Formula

$\oplus$, ♀, P_2, A_0, $\underline{G(_2)}$.

Systematic Position

Class—Dicotyledons
Sub-Class—Monochlamydeae
Series—Unisexuales
Family—Casuarinaceae

[1. Plants woody having jointed branches.
2. Leaves scale-like and whorled.
3. Inflorescence catkin.
4. Flowers unisexual, naked.
5. Placentation parietal, ovules 2 per locule.
6. Fruit mostly samara.]

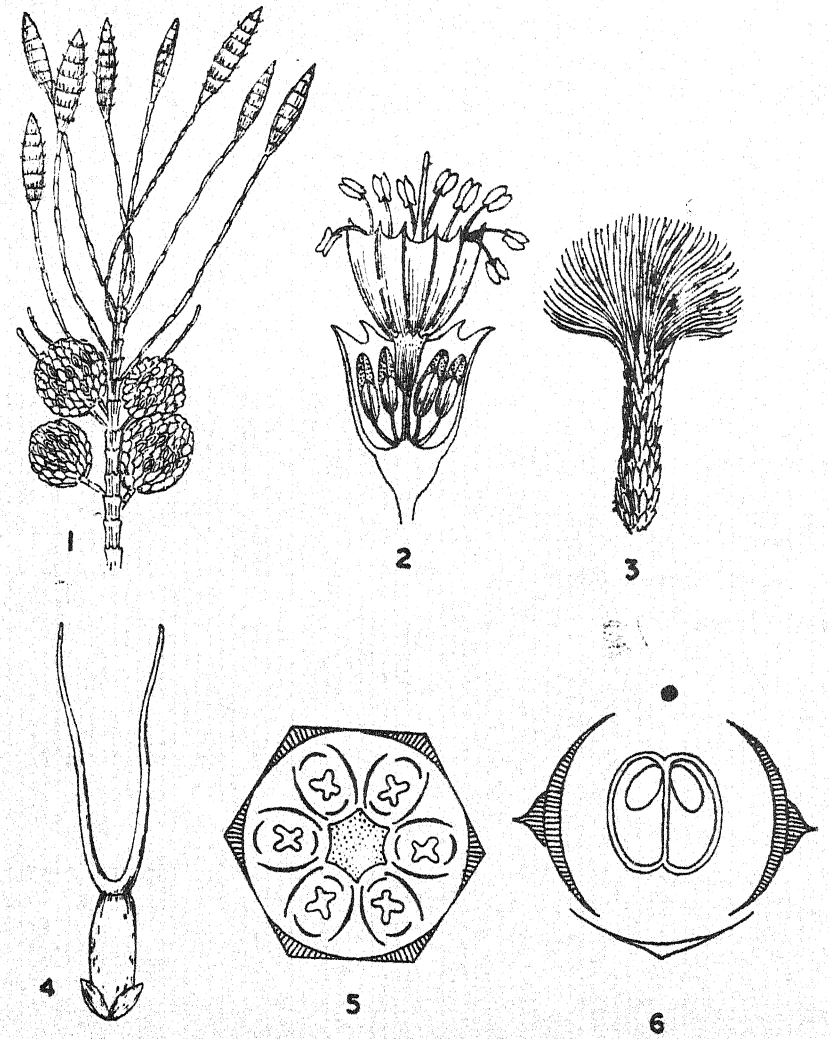


Fig. 259. *Casuarina equisetifolia* (Casuarinaceae)

1.—A Flowering twig. 2.—L. S. male inflorescence. 3.—female inflorescence. 4.—female flower 5.—floral diagram of whorl of male flowers. 6.—floral diagram of a female flower.

MONOCOTYLEDONS: ORCHIDACEAE

Example 1. *Orchis latifolia*

Habit—Herb with tuberous roots.

Root—Adventitious, tuberous, fleshy, tuberous roots store food, perennial, bear buds which sprout in next season.

Stem—Aerial, erect, reduced, unbranched, bear aerial assimilating roots.

Leaf—Simple, sessile, alternate, exstipulate, oval to linear, entire acute, fleshy, sheathing leaf base, venation parallel.

Inflorescence—Spike (racemose).

Flower—Sessile, bracteate, complete, bisexual, zygomorphic, peculiar shape, showy, epigynous, dark purple.

Perianth—Tepals 6, in 2 whorls of 3 each, polyphyllous, imbricate, outer whorl corresponding to sepals, more or less similar, inner three corresponding to petals, dissimilar, 2 lateral tepals wing like, third one dissimilar to the 2 lateral ones and is called *labellum* or *lip*, lip spotted darker, broad, shoe-like, spurred, tubular, branched variously, contains nectar secreting tissue, posterior but finaliy comes to lie on the anterior side of the flower due to the twisting of the ovary (inferior) through 180°.

Androecium—Stamens 3, 2 stamminodes, functional stamen 1, sessile, unite with the pistil to form a column, the *gynosteginm* or *gynandrium* opposite the *labellum*, anther dithecous, pollen coherent to form *pollinia*, *pollinia* viscid, attached in pairs, stalked (caudicle) to a viscid gland (disc) which lies in a small depression of the beak-like stigma or the *rostellum*, occupy the centre of the column.

Gynoecium—Tricarpellary, syncorpous, unilocular, inferior, ovary linear, twisted, placentation parietal, ovules many on each placentum, stigma 3, 2 stigma lateral, fertile, for separate 2 or 1 broad area, third stigma sterile, modified into beaked *rostellum* and lies in centre.

Fruit—Capsule.

Floral Formula

$$Br,\ \%,\ \overset{\circlearrowleft}{+},\ P_{3}+_{3},\ \overset{\frown}{A_{1}},\ \overline{G\,(_{3})}$$

Systematic Position

Class—Monocotyledons

(Venation parallel, flowers trimerous, cotyledon one)

Sub—Class—Petaloideae

(Perianth usually of 6 tepals, free or connate, members in 2 series, inner or both whorls coloured and petaloid.)

Series—Microspermae

(Flower uni or bisexual, periath 6, in 2 whorls, petaloid, onary unilocular, parietal placentation, seeds minute, numerous)

Family—Orchidaceae (Natural order)

1. Plants terrestrial, epiphytic or saprophytic.
2. Leaves usually alternate, sometimes opposite or whorled.
3. Inflorescence racemose or solitary.
4. Flower bisexual, zygomirphic, $P_{3}+_{3}$, median segment of inner whorl modified into *labellum*.
5. Stamen 1, staminodes 1 or 2, united to stylar column, *pollinia* present.
6. Gynoecium tricarpellary, syncarpous, unilocular, parietal placentation, ovules indefinite, ovary epigynous, inferior.
7. Fruit capsule.

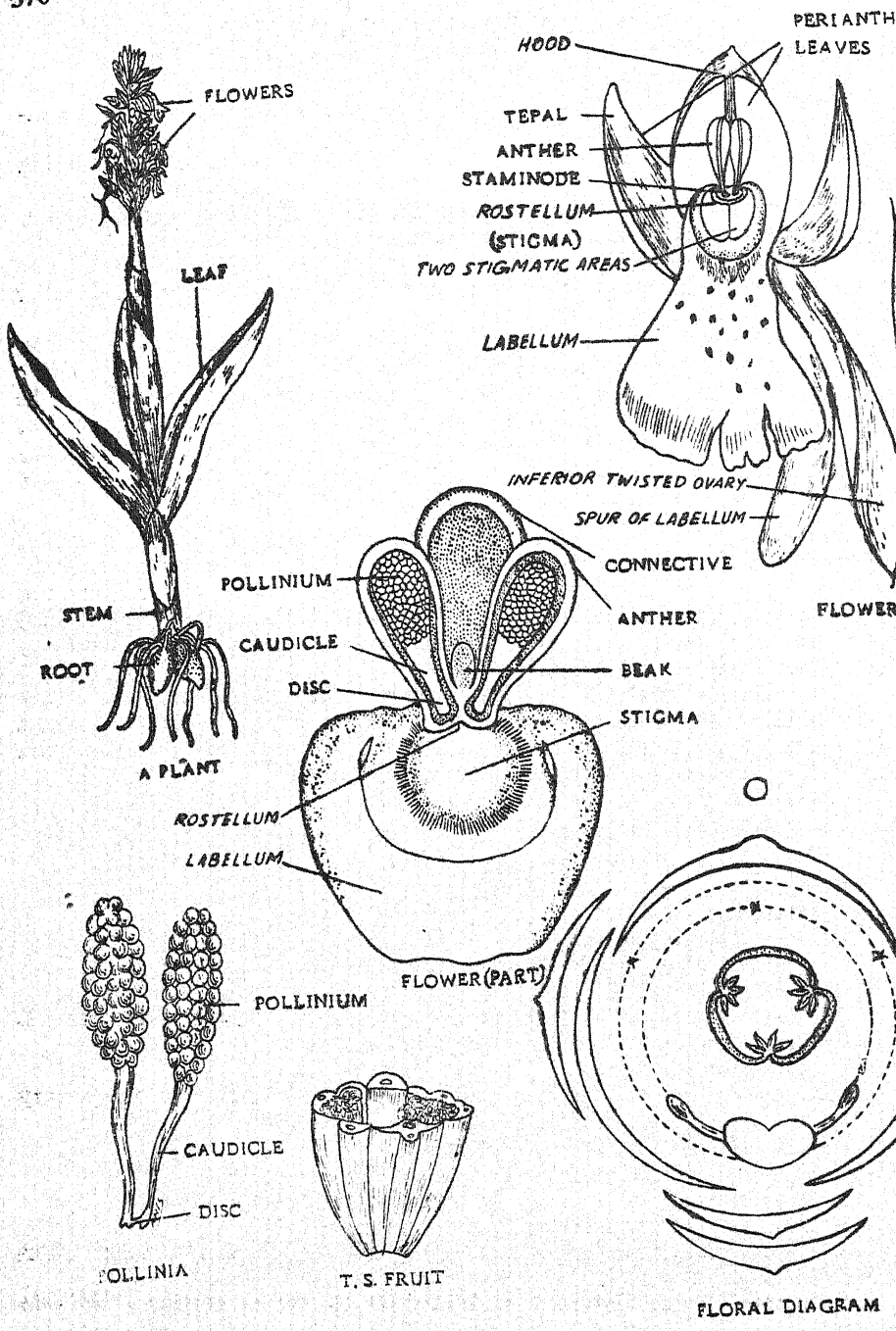


Fig. 260. *Orchis latifolia* (Orchidaceae)

LILIACEAE

Example 1. *Asphodelus tenuifolius* (Hindi—Jangalipiyaz)

Habit—Annual herb, wild.

Root—Adventitious, branched.

Stem—Rhizome (underground), reduced.

Leaf—Radical, arise in rosettes, sessile, exstipulate, leaf base sheathing, acicular, cylindrical, acute, venation parallel, glabrous.

Inflorescence—Raceme, on scape, scape aerial, erect, cylindrical, branched, solid, smooth, green.

Flower—Pedicellate, bracteate, bract broad, keeled at base, complete, bisexual, actinomorphic, trimerous, cylic, hypogynous, greenish—white.

Perianth—Tepals 6, in 2 whorls of 3 each, polyhyllous, each whorl valvate, petaloid, white with greenish ridge in the centre.

Androecium—Stamens 6, in 2 whorls of 3 each, polyandrous, epiphyllous (epitepalous), filaments of outer whorl longer than inner whorl, anther dithecous, versalite, introrse.

Gynoecium—Tricarpellary, syncarpous, trilocular, axile placentation, 2 ovules in each locule, ovary superior, style 1, long slender, stigma bilobed.

Fruit—Capsule.

Floral Formula

Br, ⊕, ♂ ♀, P 3+3, A3+3, G $\underline{(3)}$.

Systematic Position

Class—Monocotyledons

Sub-class—Petaloideae

Series—Coronariae

[1. Flowers bisexual, rarely unisexual (*Smilax*). 2. Perianth 3+3, one or both petaloid. 3. Ovary tricarpellary, syncarpous, trilocular, axile placentation, superior.]

Family—Liliaceae

[1. Flowers bisexual. 2. Perinath 6, 3+3, free or connate. 3. Stamens 6, 3+3, filaments usually free. 4. Ovary superior, 3 celled, fruit berry or capsule. 5. Plants herbs, rarely shrubs.]

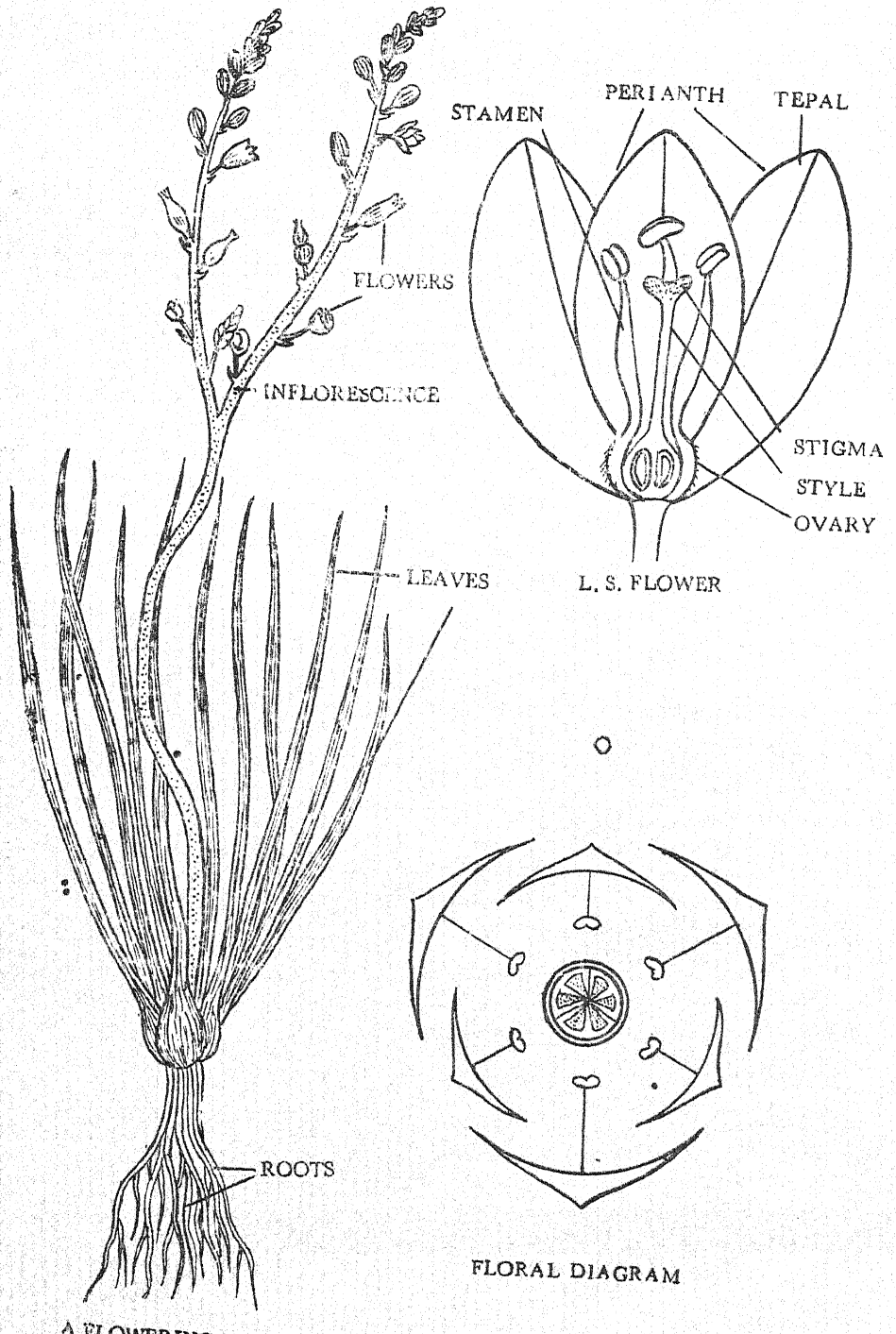


Fig. 261. *Asphodelus tenuifolius* (Liliaceae)

MUSACEAE

Example 1. *Musa paradisiaca* (Banana ; Hindi—Kela)

Habit—A cultivated, tall, perennial tree-like herb.

Root—Adventitious or fibrous.

Stem—Rhizome (underground), perennial.

Leaf—Simple, cauline, large, exstipulate, sessile, alternate, leafbase sheathing, forming below a false aerial stem, broadly elliptic, entire, obtuse, unicostate, parallel venation, glabrous.

Inflorescence—Spadix with spathe, spathe thick, violet-pink.

Flower—Sessile, bracteate, complete, bisexual, zygomorphic, trimerous, epigynous, cyclic.

Perianth—Tepals 6, gamophyllous, in 2 whorls of 3 each, posterior tepal boat shaped, free, included appendaged, rest five unite to form tube.

Androecium—Stamens 6, in two whorls of 3 each, posterior stamen abortive or absent, filament long, anther dithecous, dorsifixed, introrse.

Gynoecium—Tricarpellary, syncarpous, trilocular, axile placentation, one ovule in each locule, ovary inferior, style 1, long, stigma capitate.

Fruit—Elongated seedless berry.

Floral Formula

$$Br,\quad \%,\quad \male\!\!\female,\quad P(3+\widehat{3}),\ A\ 3+3,\quad \overline{G}_{(3)}.$$

Systematic Position

Class—Dicotyledons

Sub-class—Petaloideae

Series—Epigynae (flowers bisexual, epigynous)

Family—Musaceae (Scitamineae)

[1. Plants perennial herbs.

2. Flowers bisexual, irregular, trimerous, epigynous.

3. Perianth 6, 3+3, inner whorl petaloid.

4. Stamens 6, 3+3, in *Musa* only 5.

5. Ovary tricarpellary, syncarpous, 1—3 celled, style long, stigma capitate.]

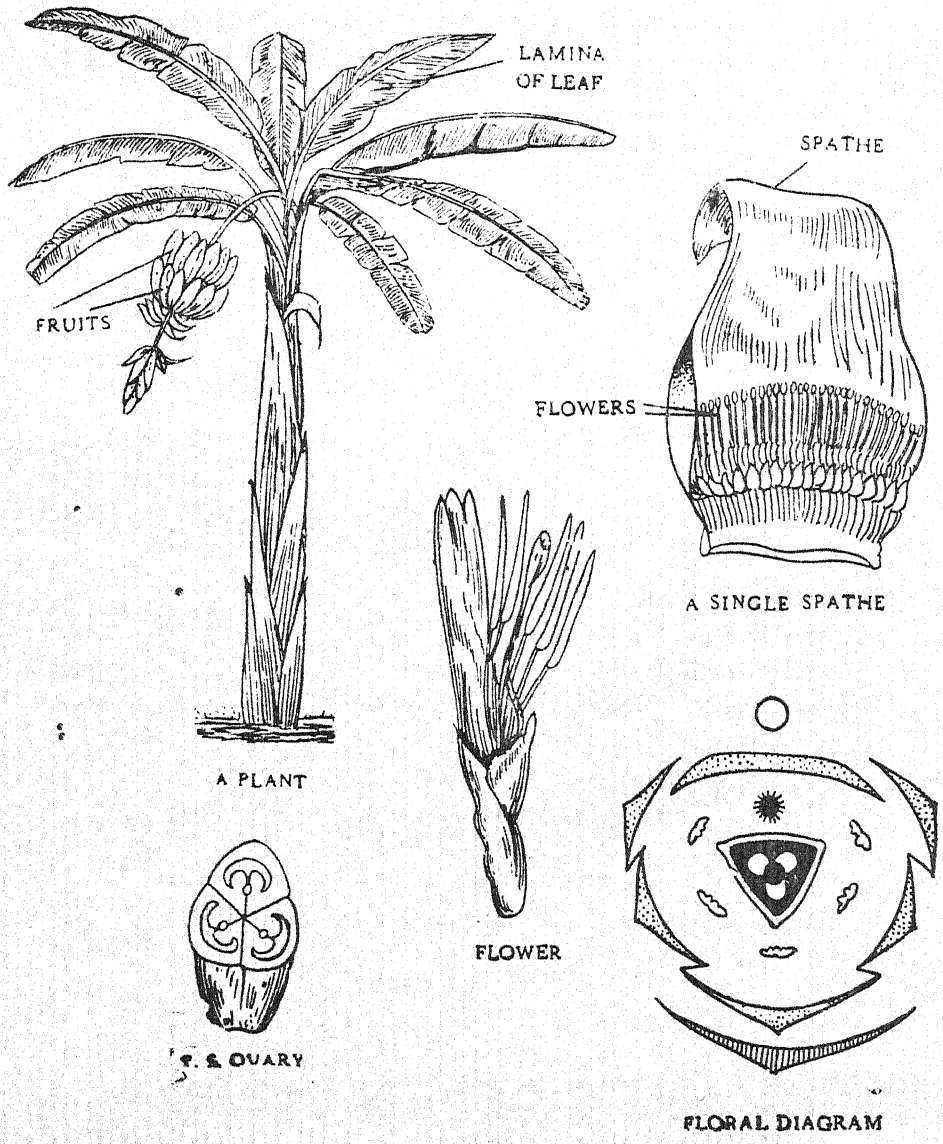


Fig. 262. *Musa paradisiaca* (Musaceae)

PALMAE (PALMACEAE)

Example 1. *Phoenix sylvestris* (*Date-palm*; *Hindi-Khajoor*)

Habit—A cultivated perennial tree.

Root—Adventitious.

Stem—Aerial, erect, columnar, cylindrical, unbranched, woody, solid, rough due to presistent leaf bases, brown.

Leaf—Petiolate, petiole stiff, flattened at base, exstipulate, leaves form a dense terminal crown, compound, unipinnate, pinnae sub-sessile, lanceolate, acute, glabrous, unicostate parallel venation.

Inflorescence—Spadix with spathe.

Flower—Sessile, ebractiate, incomplete, unisexual, trimerous, cyclic, female flower hypogynous.

Male Flower

Perianth—Tepals 6, in 2 whorls of 3 each, outer whorl gamophyllous, smaller, oddtepal anterior; forming a cupule, tepals of inner whorl larger, alternate, polyphyllous, tough, leathery, imbricate (outer whorl valvate, inner twisted).

Androecium—Stamens 6, in 2 whorls of 3 each, polyandrous, filament short, anther large, dithecous, versatile, introrse.

Gynoecium—Absent.

Floral Formula

Ebr, ⊕, ♂, $P_{(3)}+_3$, A_3+_3, Go.

Female Flower

Perianth—As in the male flower but tepals of the inner whorl smaller and twisted.

Androecium—Absent.

Gynoecium—Tricarpellary, apocarpous, ovary superior, each unilocular, plancentation basal, ovule basal, style absent, stigma uncinate.

Fruit—Berry with fleshy pericarp.

Floral Formula

Ebr, ⊕, ♀, $P_{(3)}+_3$, Ao, $\underline{G}_3$.

Systematic Position

Class—Monocotyledons

Sub-Class—Petaloideae

Series—Calycinae

(Perianth in 2 whorls, inner sepaloid or rarely petaloid, ovary superior, 1—3 celled, endosperm copious).

Family—Palmae.

[1. Plants shrubs or trees, leaves compound, stem erect.
2. Flowers unisexual, inflorescence various, with spathe (woody).
3. Perianth 6, 3+3.
4. Stamens 6, 3+3, anther versatile.
5. Ovary 1—3 celled, united or free, ovules 1 or 2 per cell.]

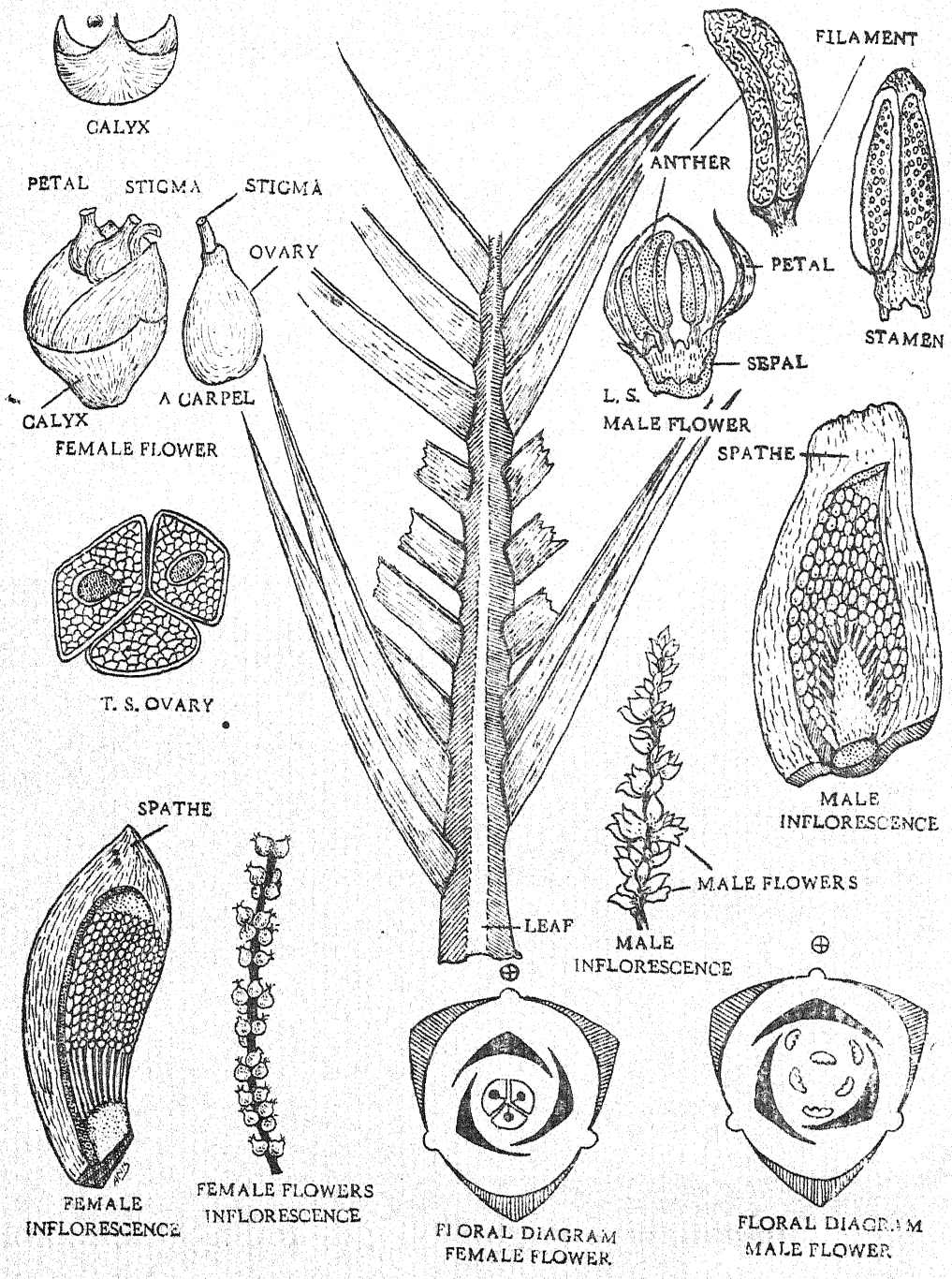


Fig. 263. *Phoenix sylvestris* (Palmae)

CYPERACEAE

Example 1. *Cyperus sp.* (Nut grass : Hindi-Motha)

Habit—A will perennial herb.

Root—Adventitious, branched, fibrous.

Stem—Basal stem rhizomatous, tuberous, tubers ovoid, aerial stem erect, unbranched, herbaceous, solid, green, triquetrous, crown of leaves present at apex.

Leaf—Cauline, simple, alternate, exstipulate three-ranked, in tufts, sheathing leaf base, fused, blade narrow, linear, grass-like, entire, acute to acuminate, surface (lower) rough, venation multicostate parallel, ligulate, ligules reduced, present at the junction of leaf base and blade.

Inflorescence—Racemose, spike of spikelets, arranged in umbel manner, axillary.

Flower—Sessile, bracteate, bract (glume) dry, greenish-brown, boat-shaped, encloses a flower, flower naked, minute, incomplete, bisexual, zygomorphic, trimerous, hypogynous.

Perianth—Absent.

Androecium—Stamens 3, 1 anterior and 2 lateral, polyandrous, filaments long, flattened, exerted, anther linear, basifixed, pointed at apex.

Gynoecium—Tricarpellary, syncarpous, unilocular, basal placentation, ovule 1, basal, ovary superior, style 1, stigma trifid, long, feathery, projecting out-side.

Fruit—Nut, compressed, trigonous.

Floral Formula

$$Br,\ \%,\ \varphi^{\delta},\ P_0,\ A_3,\ \underline{G_{(3)}}.$$

Systematic Position

Class—Monocotyledons

Series—Glumaceae (Flowers bracteate, arranged in spike, bisexual or unisexual. Perianth absent or reduced, ovary superior, 1 celled, 1 ovuled).

Family—Cyperaceae

1. Plants herbaceous.
2. Leaves mostly basal with closed sheaths.
3. Stem rhizomatous, floral branches solid, triquetrous.
4. Flowers bracteate (glume), arranged in spike of spikelets, bisexual or unisexual.
5. Perianth absent or scaly or hairy.
6. Stamens 3, basifixed.
7. Gynoecium bi or tricarpellary, syncarpous, unilocular, basal placentation, ovule 1, ovary superior, style 1—3, feather-like stigma, usually 3.
8. Fruit nut-like.

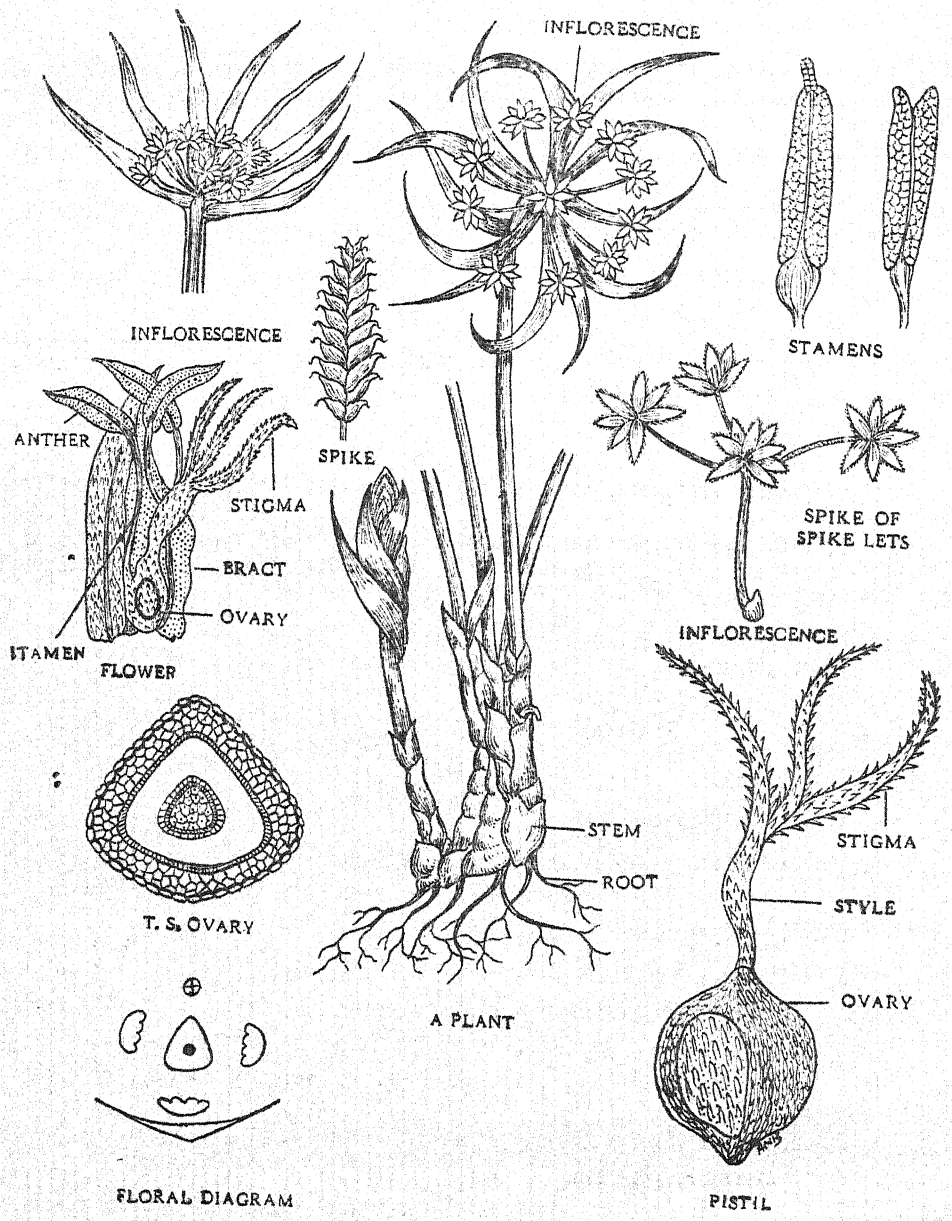


Fig. 264. *Cyperus sp.* (Cyperaceae)

GRAMINEAE (POACEAE)

Exemple 1. ***Triticum aestivum*** (Wheat ; Hindi-Genhu)

Habit—A cultivated annual herb.

Root—Adventitious, branched, fibrous.

Stem—Aerial. erect, unbranched, cylindrical, glabrous, swollen at nodes, internodes hollow, solid at nodes.

Leaf—Cauline, exstipulate, sessile, alternate, two-ranked, leaf-base sheathing, open, covering the internode (for some distance), overlapping, ligulate, ligules small, membranous, present at the junction of leaf blade and leaf base, linear-lanceolate, entire, acuminate, venation unicostate parallel.

Inflorescence—Spike of spikelets, each spikelet usually of 4 flowers, each spikelet covered by glumes.

Flower—Sessile, bracteate, incomplete, hermaphrodite (bisexual), zygomorphic, heteromerous, hypogynous, each flower covered by 2 *glumes*, anterior one is boat shaped, awned, awn long and sharply pointed, called *lemma* or *inferior palea* and is regarded as a bract ; the posterior one is thin, membranous and is called *superior palea*, regarded as a bracteole, compressed against rachilla, binerved.

Perianth—Tepals 2, reduced, thin, minute, membranous, white, called *lodicules*, placed antero-laterally.

Androecium—Stamens 3, 1 anterior, 2 lateral (postero-laterally), polyandrous, filament long, exerted, anthers dithecous, basifixed, lobes deeply divided, appear as versatile.

Gynoecium—Monocarpellary, unilocular, placentation marginal, ovule 1, ovary superior, style 2, reduced, stigma 2, long, feathery, projecting out.

Fruit—Caryopsis.

Floral Formula

$$Br,\ \%,\ \overset{\sigma}{\underset{+}{\circlearrowleft}},\ P_2,\ A_3,\ \underline{G}_1.$$

Systematic Position

Class—Monocotyledons
Series—Glumaceae
Family—Gramineae (Poaceae)

1. Plants usually herbs.
2. Roots adventitious.
3. Stem cylindrical, hollow internode.
4. Leaves lsimple, sheathing leaf base, sheath cleft, ligulate.
5. Inflorescence spike of spikelets.
6. Flower zygomorphic, hypogynous. protected by inferior and superior palea.
7. Perianth 2, represented by lodicules or absent.
8. Stamens 3, versatile.
9. Gynoecium monocarpellary, unilocular, ovule 1, basal, stigma 2, feathery.
10. Fruit a caryopsis.

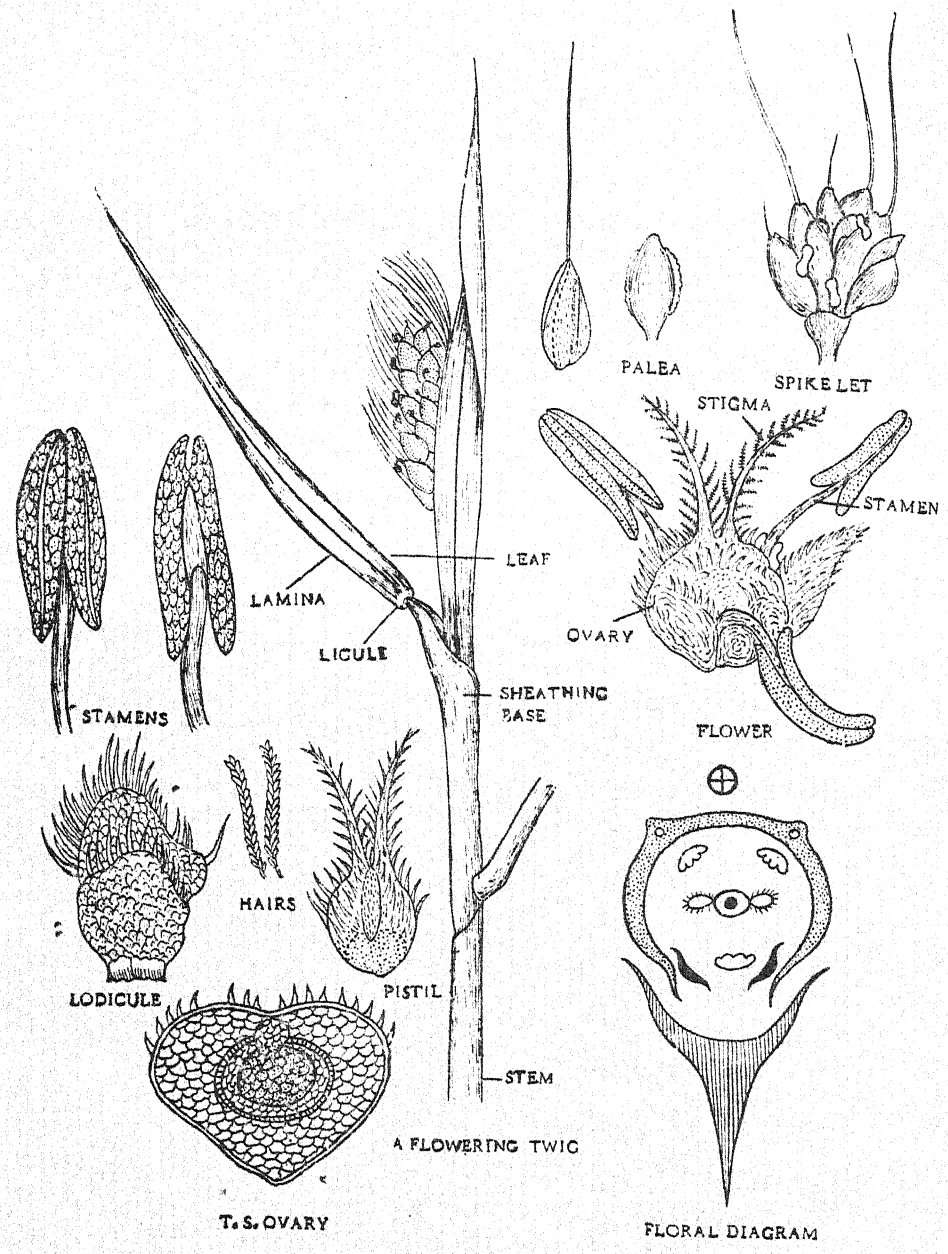


Fig. 265. *Triticum aestivum* (Gramineae)

Example 2. *Avena sativa* (Oat ; Hindi-Javi)

Habit—A cultivated annual herb.

Root—Adventitious, branched, fibrous.

Stem—Aerial, erect, cylindrical, swollen at nodes, soiid at nodes but internodes hollow, fistular, glabrous, herbaceous.

Leaf—Cauline, sessile, alternate, exstipulate, sheathing at base, blade linear, entire, acute, ligulate, ligules present at the junction of leaf blade and leafsheath, ve nation parallel, multicostate.

Inflorescence—Panicle of spikelets, each spikelet 2 or 3 flowered and covered by 2 glumes.

Flower—Sessile, bracteate, inferior and superior plea present, incomplete, bisexual, zygomorphic, hypogynous.

Perianth—Tepals 2, represenred by 2 lodicules, lodicules minute, scaly, membranous, white, placed antero-laterally.

Androecium—Stamens 3, polyandrous, one placed on anterior side, filament long, anthers dithecous, versatile.

Gynoecium—Monocarpellary, unilocular, ovule 1, basal, ovary superior. style 1, short, stigma 2, long, lateral, feathery.

Fruit—Caryopsis.

Floral Formula

Br, %, δ, φ, P_2, A_3, $\underline{G_1}$.

Systematic Position

Class—Monocotyledons

Series—Glumaceae

Family—Gramineae

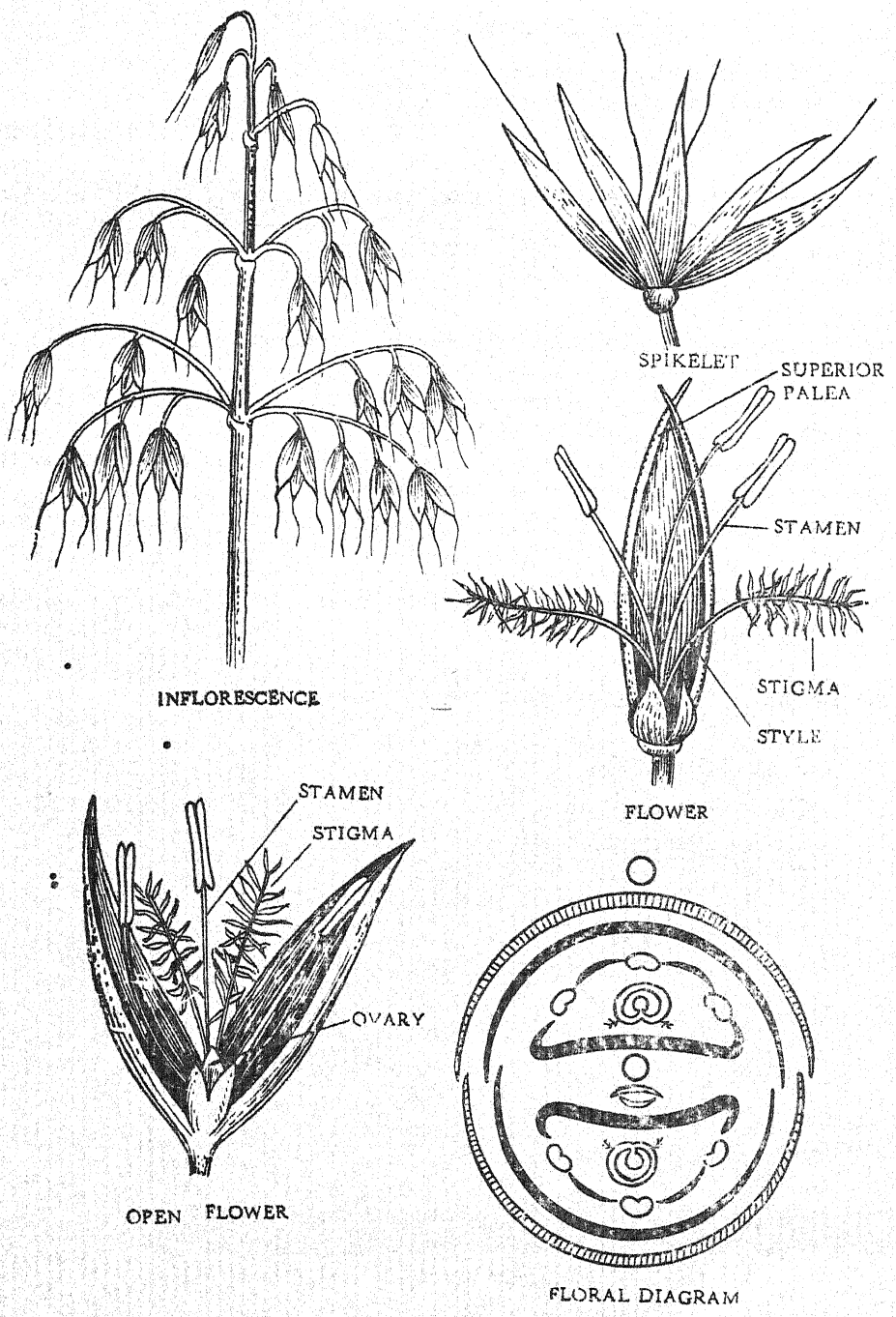


Fig. 266. *Avena sativa* (Gramineae)

Example 3. *Oryza sativa* (Rice ; Hindi-Chawal).

Habit—A cultivated annual herb.

Root—Adventitious, fibrous root.

Stem—Aerial, erect, cylindrical, swollen at node, internode hollow, node solid, herbaceous, glabrous.

Leaf—Sessile, exstipulate, simple, alternate, sheathing at base, ligulate, blade linear, entire, acute, parallel venation.

Inflorescence—Spike of spikelets.

Flower—Sessile, bracteate, superior and inferior palea present, incomplete, bisexual, zygomorphic, hypogynous.

Androecium—Stamens 6, in two whorls of 3 each, polyandrous, filament long, anther dithecous, versatile.

Gynoecium—Monocarpellary, unilocular, 1 basal ovule, superior ovary, style reduced, stigma 2, long, feathery.

Fruit—Caryopsis.

Floral Formula

$$Br,\ \oplus,\ \varsigma^{\male}_{\female},\ P_2,\ A_{3}+_{3},\ G_{1}$$

Systematic Position

Class—Monocotyledons

Series—Glumaceae

Family—Gramineae

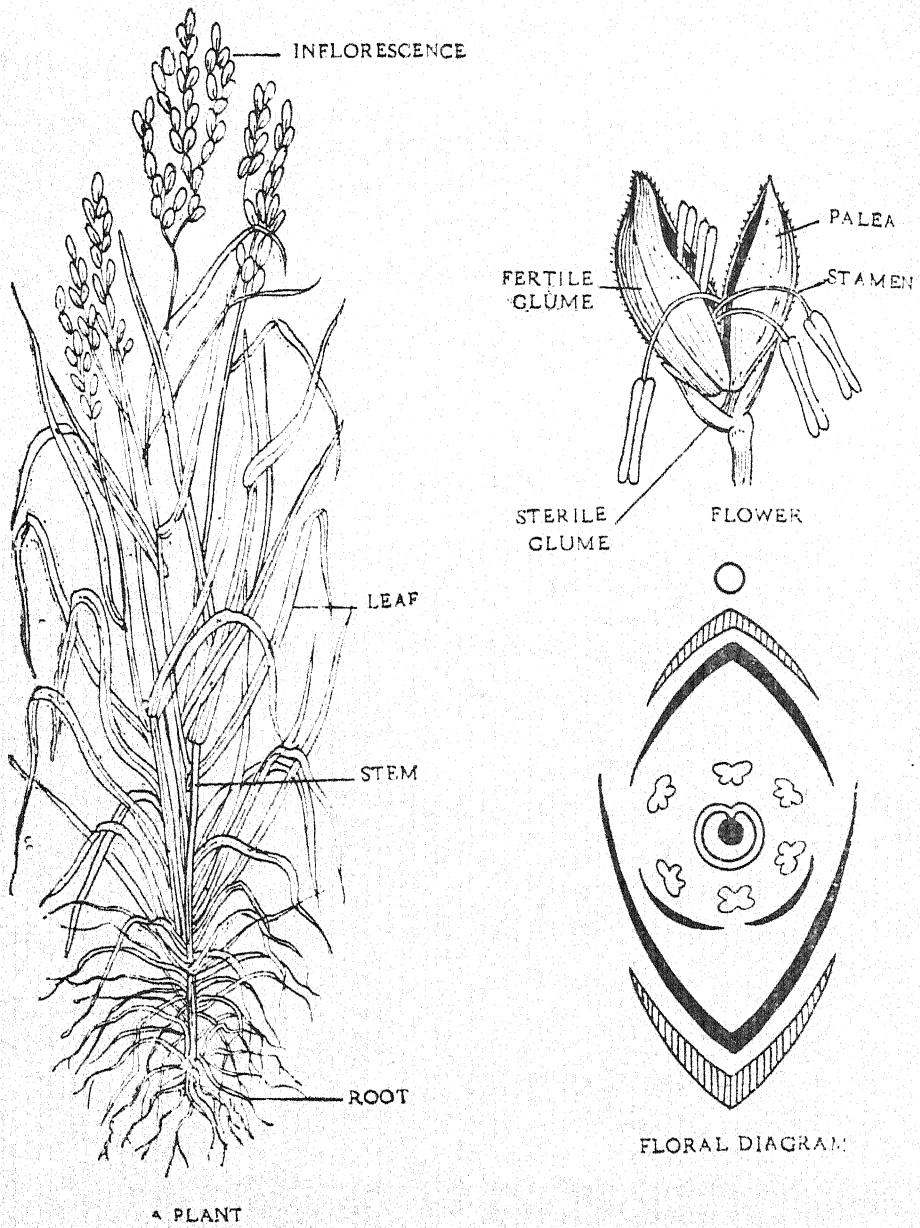


Fig. 267. ***Oryza sativa*** **(Gramineae)**

CHAPTER 7

Cytology (Cell Division)

Growth is a characteristic feature of the living organisms. There are two types of the living organisms, (i) unicellular and (ii) multicellular. In unicellular forms growth takes place by cell enlargement but in multicellular forms growth takes place by cell division. Cell division the most important method for the formation of new cells. There are two kinds of cell divisions. (i) *mitosis* and (ii) *meiosis*. Both are common in plants. In *mitosis* the chromosome pairs split and seggregate but the chromosome number remains the same. It is found in vegetative parts of the plants. *Nucleus* plays a prominent part. The nucleus divides first into 2 daughter nuclei and then cytoplasmic division (*cytokinesis*) takes place. *Mitosis* is also known as *karyokinesis*. Thus two new cells are formed in *mitosis* which are diploid. *Mitosis* is best studied in roottip cells of the Liliaceae and Gramineae (Poaceae) families.

The other type of division (*meiosis*) is found in reproductive parts. Here also the chromosomes pair, split and seggregate but the number of chromosomes become reduced to half. The reason is that during splitting the chromonemata divide but not the centromere. *Meiosis* involves two divisions, the first is *reductional* and the second is ordinary or *equational*. *Meiosis* forms 4 new cells each with reduced or haploid number or chromosomes, unlike *Meiosis* where the 2 new cells have diploid number of chromosomes. *Meiosis* is studies best in the spore mother cells or sporocytes of anthers of the families Liliaceae, Solanaceae, Papilionaceae etc.

Mitosis consists of 4 stages : (i) *prophase*, (ii) *metaphase*, (iii) *anaphase*, and (iv) *telophase* but *meiosis* consists of nine stages ; (i) *prophase I* (*leptotene, zygotene, pachytene, diplotene* and *diakinesis*) (ii) *metaphase I*. (iii)*anaphase I*. (iv) *telophase I*, (v) *interphase*, (vi) *prophase II*, (vii) *metaphase II*, (viii) *anaphase II*, and (ix) *telophase II*.

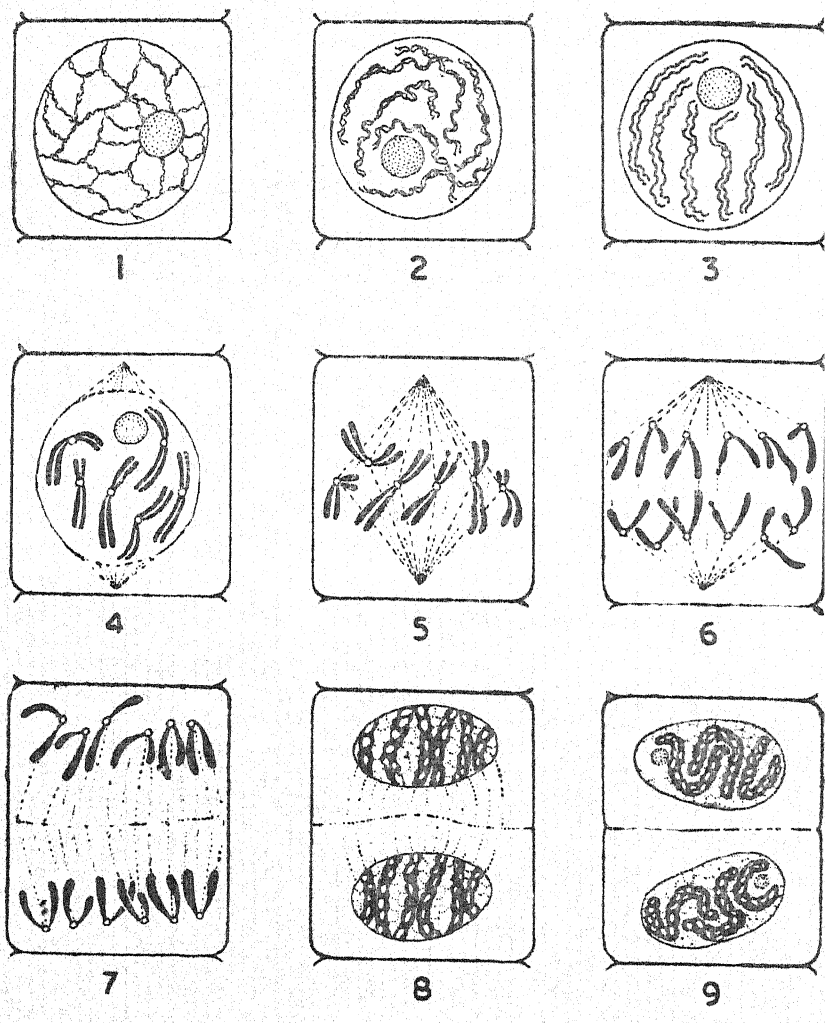


Fig. 268. Showing stages of *mitosis*.

1. Metabolic nucleus 2. Early prophase 3. Mid prophase
4. Late prophase 5. Metaphase 6. Anaphase
7, 8 & 9. Telophase.

Examine and sketch the different stages of *mitosis* in the permanent slideof l. s. of root tip under high power of the microscope.

Prophace

(1) In early prophase stage, *chromatin reticulum* opens up and the *chromosomes* become clear and well marked. Here each chromosome consists of two delicate threads which are irregularly coiled around each other. These are *chromatids* or half chromosomes.

(ii) In the mid prophase stage, the chromosomes are shorter, thicker and appear as denser bodies. Chromatids untwist.

(iii) In late prophase stage, the chromatids are thick, straight, and rod-like.

(iv) Nuclear membrane and nucleoli begin to disappear.

(v) Chromosomes are arranged randomly.

(vi) This is the *prophase* of *mitosis*.

Metasphase

(i) Appearance of fine fibrils takes place in the form of a spindle-shaped body. This spindle shaped body is called bipolar spindle or achromatic figure. The two poles of the spindle are well marked.

(ii) The chromosomes move towards centre and position themselves on the equatorial plate.

(iii) The centromeres are attached to the fibrils.

(iv) The centromeres are facing the opposite poles of the spindle.

(v) The nuclear membrane completely disappears and the chromosomes are short and distinct.

(vi) This is the *metaphase of mitosis*.

Anaphase

(i) The chromatids start separating at the centromere also and thus the two centromenes are formed. One moves towards one pole and the other to the other pole of the spindle.

(ii) One chromatid of a chromosome is dragged along with its centromere to the one pole while the other is dragged with the centromere to the other pole of the spindle.

(iii) The chromosomes now become inverted V or L-shaped in appearance and are attached to the spindle.

(iv) Each pole has as many chromatids as there were chromosomes originally in the parent cell of the root-tip.

(v) This is the *anaphase* of *mitosis*.

Telophase

(i) The chromosomes are short, twisted and coiled i. e. they are indistinct and show regrouping into nucleus.

(ii) Nuclear membrane and nucleoli begin to reappear.

(iii) Cell plate formation (cytokinesis) begins in the centre and extends towards the periphery (in animals it starts from the priphery).

(iv) Finally two daugher cells are formed, each with its own nucleus.

(v) This is the *telophase* of *mitosis*.

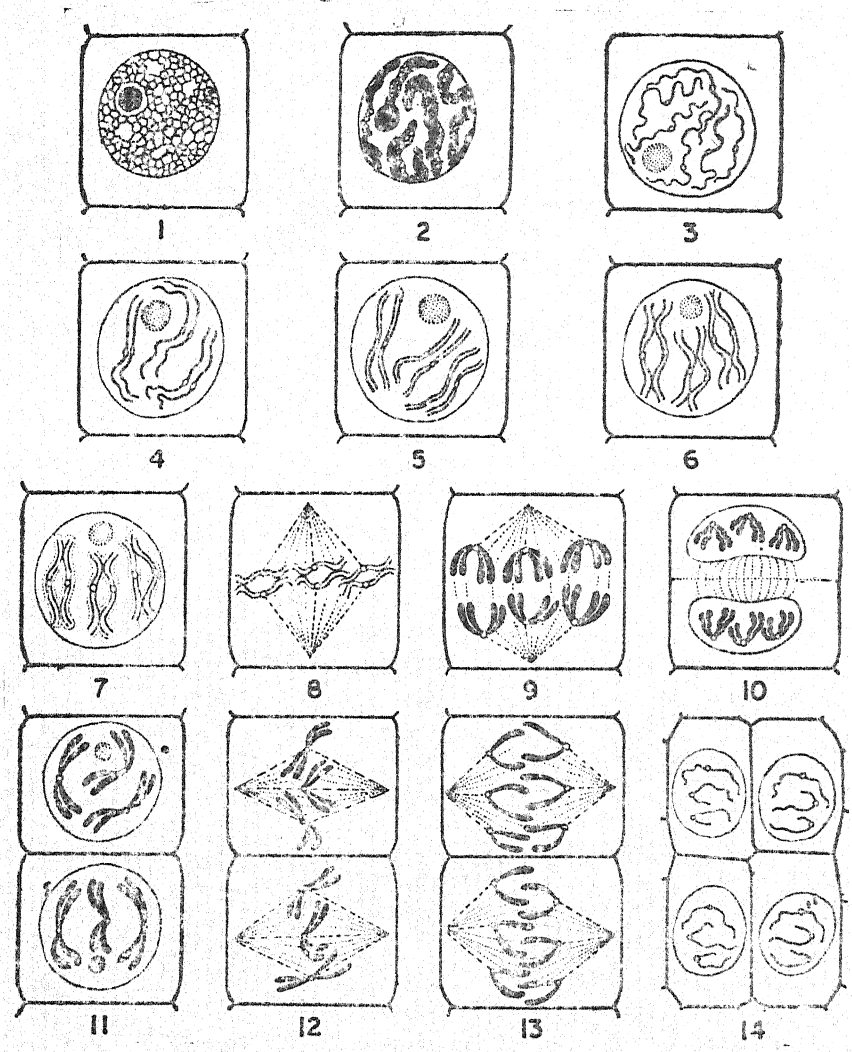


Fig. 269. Showing stages of *meiosis*.
1, 2 & 3. Meiosis I (Leptotene) 4. Zygotene 5. Pachytene 6. Diplotene 7. Diakinesis 8. Metaphase I. 9. Anaphase I 10. Telophase I. 11. Meiosis II. Prophase II. 12. Metaphase II, 13. Anaphase II. 14. Telophase II.

Examine and sketch the permanent slides of the t. s. of anther showing different stages of *meiosis* under high power of the microscope.

Meiosis comprises two divisions, (i) first meiotic division or meiosis I and (ii) second meiotic division or meiosis II. *Meiosis* forms 4 haploid cells unlike *mitosis* where only two cells are formed with the same chromosomes.

Meiosis I

Prophase I—This starts with the first or earliest changes in the nucleus. It consists of a number of complicated stages and takes a long duration. Its various sub-stages are :

(i) *Leptotene* (ii) *Zygotene* (iii) *Pachytene* (iv) *Diplotene* (v) *Diakinesis.*

Leptotene

1. This is the earliest stage of prophase I of meiosis.
2. The nuclear membrane and nucleolus are seen but they begin disintegration.
3. The chromatin net work uncoil or open out and clear threads are seen.
4. The chromosomes are long, thin and slender and this stage is also called the thin thread stage.
5. Here the chromosome number is diploid.

Zygotene

1. This is the second stage of prophase I of meiosis.
2. Here, pairing of two homologous chromosomes begins lengthwise and this is termed as *synapsis*. This is also known as joining thread stage.
3. The nuclear membrane and nucleolus are faintly visible and are disintegrating.
4. The chromosomes are randomly distributed and they become shorter and thicker.
5. *Synapsis* starts at one or more than one points and often at centromeres. It proceeds side by side till they are fully apposed.

Pachytene

1. This is the third stage of prophase I of meiosis.
2. The two joining chromosomes becomes intimately associated, so much so that it is difficult to know that they are composed of two chromosomes. These pairs are known as ***bivalents.***
3. The paired chromosomes become thick and short. This is also known as thick thread stage.
4. The nuclear membrane is almost distintegrated but the nucleolus is very faint.
5. Longitudinal splitting of chromonemata is seen but the centromere does not divide. Thus the number of chromonemata become double.

Diplotene

1. This is the fourth stage of prophase I of meiosis.

2. The threads appear to be separating rom one an other and each synaped pair consists of 4 threads and is called the *tetrad*. This stage is also known as double thread stage.

3. The chromatids are attached to one or more points. These points of attachment are known as *chiasmata*. Thus the separation is not complete.

4. The chiasmata formation results in crossing-over where interchange of comparable segments between homologous chromatids takes place.

5. The chromosomes are very short and thick and matrix becomes visible or evident.

Diakinesis

1. This is the last or the fifth stage of prophase I of meiosis.

2. The threads are completely separated.

3. Nuclear membrane and the nucleolus begin to disappear.

4. The chromosomes are very short, randomly distributed and their individuality becomes clear. Each chromosome contains double number of chromonemata.

5. This is quite suitable for counting the number of the chromosomes.

Metaphase I

1. Nuclear membrane and nucleolus are not seen.

2. Spindle formation takes place.

3. The chromosomes move towards middle region of the spindle i. e., *equator*.

4. The chromatids are still connected by chiasmata and move to the equatorial plate as tetrads. The centromeres of the chromosomes face the poles.

5. This is metaphase I of meiosis.

Anaphase I

1. This is anaphase I of meiosis.

2. The movement of the chromosomes towards the poles begins.

3. The centromeres of the tetrads get separated and the two chromatids move towards the opposite poles as diads. One half of the chromosomes move towards one pole and the other half towards the other pole.

4. The maternal and the paternal chromosomes get separated.

5. Each diad is made up of chromatid which has both maternal and paternal segments formed as a result of chiasmata formation and crossing over.

Telophase I

1. This is the telophase I stage of meiosis and is found after anaphase I.

2. The chromosomes present at the two poles regroup themselves into nuclear structure.

3. The nuclear membrane and nucleolus reappear.

4. The two daughter nuclei thus formed are quite large and the chromatids are seen as long and slender threads.

5. Cytokinesis takes place and cell plate is formed and the daughter nuclei appear to be similar to the nuclei before the begining of the cell division.

Note

There is a stage when coilings and the stainability is lost and the chromosomes are not seen. This stage of meiosis is known as the *interphase.*

Meiosis II

Meiosis II consists of last 4 stages of meiosis namely prophase II, metaphase II, anaphase II and telophase II. These stages are similar to mitosis. For these stages the students are advised to go through the description of mitosis given before meiosis.